TABLE OF CONTENTS

Page

INTRODUCTION 1

METHODS AND MATERIALS. 4

RESULTS 32

DISCUSSION 182

RECOMMENDATIONS. 188

ACKNOWLEDGMENTS. 189

REFERENCES 190

APPENDIX A 192

APPENDIX B 215

APPENDIX C 225

APPENDIX D 284

APPENDIX E 286

APPENDIX F 290

LIST OF FIGURES

Figure Page

1. Provincial location of lakes surveyed in 1977 (○) and 1978 (●) 5
2. Pine II Lake 7
3. Grandmother Lake 8
4. Fraser Lake 9
5. James Lake 10
6. McPherson Lake 11
7. Lake "X" 12
8. Enatik I and II Lakes 13
9. Whitefish Lake 14

Figure Page

10. Numakoos Lake 15

11. Unagimau Lake 16

12. Barlow and Pine I Lakes 17

13. Magrath Lake 18

14. Hurst Lake 19

15. McAgree Lake 20

16. Melvin Lake 21

17. McFadden Lake 22

18. MacBride Lake 23

19. MacKerracher I and II Lakes 24

20. Denison Lake 25

21. Aswapiswanan Lake 26

22. Wass Lake. Contour interval = 3 m . . . .

23. Cuddle Lake. Contour interval = 5 m . . . .

24. Bearhead Lake. Contour interval = 5 m . . . . . .

25. Fairy Rock Lake. Contour interval = 5 m . . . . .

26. Max Lake. Contour interval = 5 ft . . . .

27. Ankle Lake. Contour interval = 5 m . . . .

28. Willow Lake. Contour interval = 2 m . . . .

29. Semple Lake. Contour interval = 3 m . . . .

Figure Page

30. Walford plots for walleyes from Denison (A), Willow (B), Ankle (C), Mackerracher I (D), Mackerracher II (E) and Bearhead (F) Lakes 59

31. Walford plots for walleyes from X(A), Fairy Rock (B), Wass (C), Cuddle (D), Aswapiswanan (E) and Max (F) Lakes. 60

32. Walford plots for walleyes from Enatik (A) and Semple (B) Lakes 61

33. Walford plots for whitefish from Ankle (A), Bearhead (B), Denison (C), Mackerracher I (D), Mackerracher II (E) and Willow (F) Lakes 62

34. Walford plots for whitefish from Enatik (A), Max (B), Aswapiswanan (C), Cuddle (D), Whitefish (E) and Numakoos (F) Lakes 63

35. Walford plots for whitefish from Pine (A), James (B), MacPherson (C), Semple (D) and Fairy Rock (E) Lakes 64

36. Walford plots for pike from Wass (A), Semple (B), Fairy Rock (C), MacBride (D), MacPherson (E) and X (F) Lakes 65

37. Walford plots for pike from Enatik (A), Willow (B), Denison (C), Mackerracher I (D), Mackerracher II (E), and Bearhead (F) Lakes 66

38. Walford plots for pike from Ankle (A), Numakoos (B), Pine (C) Whitefish (D), Cuddle (E) and Max (F) Lakes 67

Figure Page

39. Von Bertalanffy growth curves of pike from MacPherson (1), Ankle, (2), Bearhead (3) and James (4) Lakes . . 78

40. Von Bertalanffy growth curves of pike from Willow (1), Denison (2), MacBride (3) and Enatik (4) Lakes. . . . 79

41. Von Bertalanffy growth curves of pike from Mackerracher II (1), Max (2), Whitefish (3), Semple (4) and Cuddle (5) Lakes 80

42. Von Bertalanffy growth curves of pike from Mackerracher I (1), Numakoos (2), Fairy Rock (3) and Wass (4) Lakes 81

43. Von Bertalanffy growth curves of whitefish from Max (1), MacPherson (2), Fairy Rock (3) and Pine (4) Lakes 82

44. Von Bertalanffy growth curves of whitefish from Mackerracher I (1), Bearhead (2), Aswapiswanan (3), and Mackerracher II (4) Lakes 83

45. Von Bertalanffy growth curves of whitefish from Numakoos (1), James (2), Semple (3), Whitefish (4) and Ankle (5) Lakes 84

46. Von Bertalanffy growth curves of whitefish from Willow (1), Enatik (2), Cuddle (3) and Denison (4) Lakes 85

47. Von Bertalanffy growth curves of walleyes from Mackerracher I (1), Aswapiswanan (2), Denison (3) and Enatik (4) Lakes 86

Figure Page

48. Von Bertalanffy growth curves of walleye from Wass (1), Bearhead (2), Cuddle (3) and Fairy Rock (4) Lakes 87

49. Von Bertalanffy growth curves of walleyes from Max (1), Willow (2), Ankle (3) and Mackerracher II (4) Lakes 88

50. Exponential growth curves of walleyes from Bearhead (A), Mackerracher I (B), Mackerracher II (C), Denison (D), Willow (E) and Enatik (F) Lakes 89

51. Exponential growth curves of walleyes from Max (A), Aswapiswanan (B), Cuddle (C), and X (D) Lakes and pike from Ankle (E) and Bearhead (F) Lakes . . . 90

52. Exponential growth curves of pike from MacPherson (A), MacBride (B), Fairy Rock (C), Semple (D) and Wass (E) Lakes 91

53. Exponential growth curves of pike from Cuddle (A), Whitefish (B), Pine (C), Numakoos (D), James (E) and X (F) Lakes 92

54. Exponential growth curves of pike from Mackerracher I (A), Mackerracher II (B), Denison (C), Willow (D), Enatik (E) and Max (F) Lakes 93

55. Exponential growth curves of whitefish from Denison (A), Bearhead (B), Ankle (C), Mackerracher I (D), Mackerracher II (E) and Willow (F) Lakes 94

Figure Page

56. Exponential growth curves of whitefish from Numakoos (A), James (B), MacPherson (C), Fairy Rock (D) and Semple (E) Lakes and of walleyes from Ankle (F) Lakes 95

57. Exponential growth curves of whitefish from Enatik (A), Max (B), Aswapiswanan (C), Cuddle (D), Whitefish (E) and Pine (F) Lakes 96

58. Walleye maturity curves 103

59. Whitefish maturity curves 104

60. Pike maturity curves 105

61. Age compositions of walleyes 107

62. Age compositions of pike 108

63. Age compositions of whitefish 110

64. Catch curves of walleyes from Semple (A), Aswapiswanan (B), Ankle (C), Bearhead (D), Mackerracher I (F), Mackerracher (G), Cuddle (H), Wass (I) and Denison (J) Lakes 113

65. Catch curves of walleyes from Willow (A), Enatik (B), Max (C) and Fairy Rock (D) Lakes and of whitefish from Aswapiswanan (E), MacPherson (F) Ankle (G), Bearhead (H), Pine (I) and James (J) Lakes 114

66. Catch curves of whitefish from Numakoos (A), Mackerracher I (B), Mackerracher II (C), Cuddle (D), Denison (E), Willow (F), Enatik (G), Max (H), Whitefish (I) and Fairy Rock (J) Lakes 115

Figure Page

67. Catch curves of whitefish from Semple Lake (A), and pike from Ankle (B), Bearhead (C), Pine (D), James (E), Numakoos (F), X (G), Mackerracher I (H), Mackerracher II (I) and Cuddle (J) Lakes 116

68. Catch curves of pike from Semple (A), Wass (B), Denison (C), Willow (D), Enatik (E), Max (F), Whitefish (G), MacBride (H) and Fairy Rock (I) Lakes. 117

69. Differences among scale ages, mean otolith ages (■) and mean spine ages (▲) of Semple Lake walleyes 120

70. Differences among scale ages, mean otolith ages (■) and mean spine ages (▲) of Wass Lake walleyes 121

71. Differences among scale ages, mean otolith ages (■) and mean spine ages (▲) of Ankle Lake whitefish. 122

72. Differences among scale ages, mean otolith ages (■) and mean spine ages (▲) of Aswapiswanan Lake walleyes 123

73. Differences among scale ages, mean otolith ages (■) and mean spine ages (▲) of Willow Lake walleyes 124

74. Differences among scale ages, mean otolith ages (■) and mean spine ages (▲) of Fairy Rock Lake walleyes 125

Figure Page

75. Differences among scale ages, mean opercular ages (■) and mean fin ray (▲) ages of Fairy Rock Lake pike. 126

76. Differences among scale ages, mean opercular ages (■) and mean fin ray ages (▲) of Wass Lake pike . 127

77. Differences among scale ages, mean opercular ages (■) and mean fin ray ages (▲) of Semple Lake pike 128

78. Differences among scale ages, mean opercular ages (■) and mean fin ray ages (▲) of Willow Lake pike 129

79. Differences among scale ages, mean opercular ages (■) and mean fin ray ages (▲) of Ankle Lake pike. 130

80. Differences among scale ages, mean opercular ages (■), and mean fin ray ages (▲) of Whitefish Lake pike . 131

81. Differences among scale ages, mean otolith ages (■), and mean fin ray ages (▲) of Fairy Rock Lake whitefish 133

82. Differences among scale ages, mean fin ray ages (■) and mean otolith ages (▲) of Whitefish Lake whitefish 134

83. Differences among scale ages, mean otolith ages (■) and mean fin ray ages (▲) of Semple Lake whitefish 135

84. Differences among scale ages, mean otolith ages (■) and mean fin ray ages (▲) of Aswapiswanan Lake Whitefish 136

Figure Page

85. Differences among scale ages and mean fin ray ages of Ankle Lake whitefish 137

86. Daily catches of all species by group 1 from Denison Lake 141

87. Daily catches of all species by group 2 from Denison Lake 142

88. Daily catches of all species by group 3 from Denison Lake 143

89. Total daily catches of walleyes from Denison Lake 144

90. Total daily catches of pike from Denison Lake . . 145

91. Total daily catches of whitefish from Denison Lake 146

92. Daily catches of all species by all groups of fishermen from Denison Lake 148

93. Total daily catches of walleyes from Mackerracher I Lake. 152

94. Total daily catches of pike from Mackerracher I Lake 153

95. Total daily catches of whitefish from Mackerracher I Lake 154

96. Total daily catches of walleyes from Mackerracher II Lake 155

97. Total daily catches of pike from Mackerracher II Lake 156

98. Total daily catches of whitefish from Mackerracher II Lake 157

Figure Page

99. Total daily catches of all species from Mackerracher I Lake 159

100. Daily catches of all species from Mackerracher II Lake 160

101. Relationship of mean catch per gang and mean depth . 171

102. Relationship of mean catch per gang and [T.D.S.] for shallow lakes (curve A) and deep lakes (curve B) 174

103. Relationship of mean catch per gang and M.E.I. . . . 175

104. Relationship of mean catch per gang and conductivity of lake waters 176

105. Relationship of mean catch per gang and trophic state indices for all lakes (curve A), shallow lakes (curve B), and deep lakes (curve C). 178

106. Relationship of the log of the mean catches per gang and trophic state indices 179

107. Relationship of mean catch per gang corrected for mean depth and trophic state indices 180

108. Relationship of the log of mean catch per gang corrected for mean depth and trophic state indices . 181

LIST OF TABLES

Table Page

1. Locations, activities and sampling dates for pulse fishing lakes, 1977 - 1978 6
2. Station depths 27
3. Morphometry, morphoedaphic indices and predicted yields of depth-sounded lakes 34
4. Trophic state indices of surveyed lakes 35
5. Conductivity and residue of surveyed lakes 36
6. Alkalinity and pH of surveyed lakes. 39
7. Species composition determined from gillnet catches 43
8. *Triaenophorus crassus* infestation levels in whitefish, 1977 45
9. *Triaenophorus crassus* infestation levels in whitefish, 1978 46
10. Regressions of mercury content (mg l^{-1}) on body size of pike and walleyes 47
11. Age compositions and mean lengths and weights of walleyes, pike and whitefish from surveyed lakes . 49
12. Age-specific mean length - mean weight relationships of walleyes, pike and whitefish 56
13. Linear equations of Walford plots fitted by regressions. 68
14. Relationships of $\log_e (L_\infty - l_t)$ and t for walleyes, pike and whitefish from surveyed lakes . 71
15. Exponential and von Bertalanffy growth curves of walleyes, pike and whitefish 74

Table Page

16. Stepwise ANCOVA comparing Brody growth coefficients of pike 97

17. Stepwise ANCOVA comparing Brody growth coefficients of walleyes 98

18. Stepwise ANCOVA comparing Brody growth coefficients of whitefish 99

19. Age-specific maturity frequencies (%) of walleyes, whitefish and pike used to derive maturity curves listed on Table 20 100

20. Maturity curves of walleyes, pike and whitefish . . 101

21. Stepwise ANCOVA comparing instantaneous maturity rates of walleyes, whitefish and pike 106

22. Robson-Chapman and regression estimates of walleye, pike and whitefish mortality rates 118

23. Regression analyses of round and dressed weights of commercially caught fish 138

24. Daily catches (lbs. dressed wt.) of three groups of fishermen on Denison Lake 139

25. Regressions of daily catches of Denison Lake fishermen 147

26. Daily catches (lbs. dressed weight) from the Mackerracher Lakes 150

27. Regression analyses of Mackerracher Lake's commercial catch 158

28. Daily catches (lbs. dressed weight) of two groups of fishermen on MacBride Lake 162

Table Page

29. Regression analysis of MacBride Lake commercial catch 163

30. Daily catches (lbs. dressed weight) of two groups of fishermen on Enatik I and II Lakes 164

31. Regression analyses of Enatik I and II commercial catches 165

32. Daily catches (lbs.) of three fishermen on Max Lake 166

33. Summary of commercial catches 167

34. Predicted and actual yields and quotas of commercially fished lakes 168

35. Parameters used in derivations of trophic relationships 170

36. Regression analyses of trophic state relationships. 172

INTRODUCTION

In 1977, the Fisheries Program section, Man. Dept. of Renewable Resources and Transportation Services, in cooperation with the Fisheries and Marine Service, Environment Canada, initiated a pulse fishing project on some small, remote lakes in northern Manitoba. According to the pulse fishing concept, a lake is intensively fished without a quota restriction until it becomes economically unfeasible to continue fishing. This lake is not fished again for a few years. This allows fish stocks to recover their original abundances at which time the lake can be intensively fished again. While one lake is recovering, another lake can be pulse fished. Thus the program can operate on a continuing basis.

The pulse fishing project consists of three phases:

1) lakes are surveyed to obtain biological information relating to the feasibility of commercial fishing.

2) if a lake is deemed to be a suitable candidate for pulse fishing, local fishermen are allowed to fish that lake with legal mesh size nets as long as they desire. Commercial catches are monitored on a daily basis.

3) pulse fished lake is monitored to determine how fish stocks are recovering.

The broad objectives of the pulse fishing project were:

1) to test the economical and biological feasibility of the pulse fishing concept in northern Manitoban lakes. The ultimate intent was to provide increased economic opportunities and returns for northern Manitoban fishermen.

2) to recommend whether or not pulse fishing is a viable management option.

3) to determine the feasibility of portable fish storage facilities.

When this project was initiated in 1977, the criteria used to choose lakes for pulse fishing were rather generalized:

1) lakes had to be relatively small.

2) lakes had to be relatively close to a fish packing plant.

3) lakes must not have been fished for at least five previous years.

4) lakes had to contain walleyes.

Due to low yields of poor quality fish caught in 1977 by relatively unindustrious fishermen, the criteria used to choose lakes for pulse fishing and for baseline surveys in 1978 were somewhat more refined:

1) lakes had to contain "export" quality (< 40 *Triaenophorus crassus* cysts per 100 lbs) whitefish and/or

2) lakes had to contain a walleye population that was relatively uncontaminated with mercury (i.e. a "monitor" classification).

3) large lakes supporting a continuing commercial fishery could not be chosen as prospective candidates.

This report presents results of the biological surveys and commercial sampling programs conducted in 1977 and 1978. The objectives of this study were:

1) to provide physical and chemical descriptions of the surveyed lakes
2) to determine the major zooplankton, phytoplankton, and benthic species present in surveyed lakes
3) to determine major cyprinid species present in surveyed lakes
4) to estimate some population parameters of fish stocks present in surveyed lakes
5) to describe commercial fishing operations on pulse fished lakes
6) to evaluate the use of portable fish storage facilities
7) to discuss implications of the pulse fishing concept in northern Manitoba.

Due to the termination of the pulse fishing project in 1978, some of the study lakes were not experimentally netted. Only limnological data were collected from some lakes. A few lakes were pulse fished but were not monitored later to determine if fish stocks were recovering.

METHODS AND MATERIALS

Limnological sampling

Lakes that were surveyed or fished during 1977 and 1978 are shown on Fig. 1. Locations, activities and sampling dates for these lakes are listed in Table 1. The climate, geology, biota, geography, and economic activities associated with these lakes is described in Weir (1960).

Locations of limnological stations, seining sites and gillnetting locations are shown on Figs. 2 to 29. Figs. 22 to 29 are located at the end of this report. Limnological stations are indicated by ● , seining sites are indicated by ▲ and gillnet locations are indicated by □ . Depths of limnological stations are listed in Table 2.

Limnological sampling

Denison, MacKerracher I and II, MacBride, Whitefish, Semple, Willow, Bearhead, Wass, Cuddle, Ankle, Max, Aswapiswanan and Fairy Rock lakes were depth-sounded. Depths along transects were determined with a Furuno depth sounder (model FG - 11/200 Mark - 3). Contour areas were measured with a Hewlett Packard digitizer.

Temperature and oxygen profiles were recorded at one station on each lake with an electronic thermistor/O_2 probe (Yellow Springs Instruments). Readings were obtained at 1 m depth intervals from the top to the bottom of each station.

Secchi disc transparency was recorded at each station.

The pH of surface water of each station was measured with an

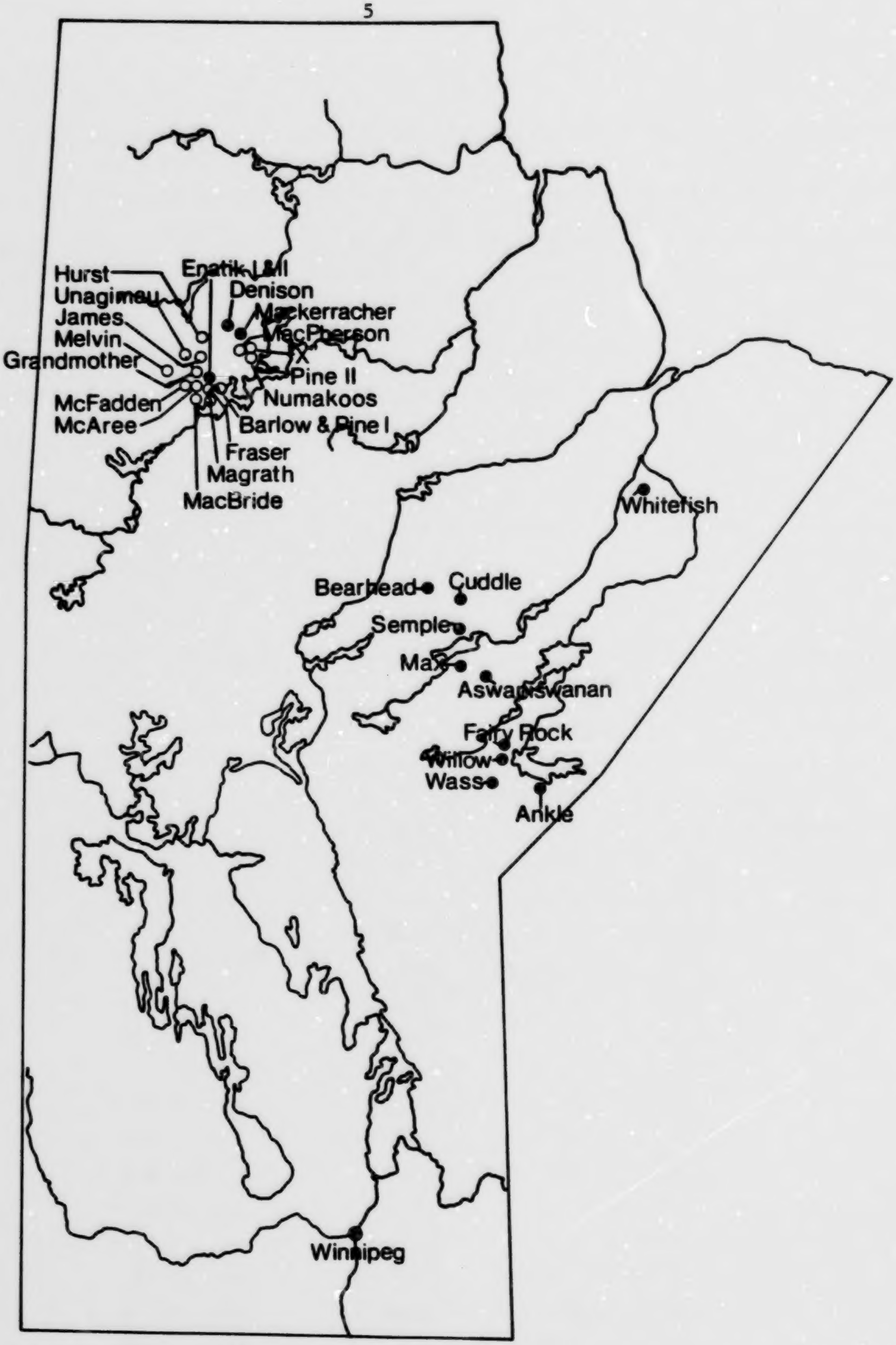
Hurst
Unagimeu
James
Melvin
Grandmother
McFadden
McAree
Enatik I&II
Denison
Mackerracher
MacPherson
X
Pine II
Numakoos
Barlow & Pine I
Fraser
Magrath
MacBride
Whitefish
Bearhead
Cuddle
Semple
Max
Aswapiswanan
Fairy Rock
Willow
Wass
Ankle
Winnipeg

Fig. 1. Provincial location of lakes surveyed in 1977 (○) and 1978 (●).

Table 1. Locations, activities and sampling dates for pulse fishing lakes, 1977 - 1978.

Lake	Location		Activity		
	Latitude (0")	Longitude (0")	Limnological sampling	Experimental Netting	Commercial fishing
MacKerracher I and II	5729	9921	Aug. 16/77	June 6-22/77	June 7-July 20/77
Denison	5730	9930	Aug. 16	July 30-Aug. 4	July 24-Aug. 21
Unagimau	5718	10000	Aug. 17		
James	5715	9945	Aug. 17	Aug. 26	
Melvin	5708	10014	Aug. 23		
Grandmother	5706	9958	Aug. 18		
Enatik I and II	5704	9937	Aug. 23		June 13-28
McFadden	5658	9958	Aug. 19		
McAree	5656	9950	Aug. 19		
MacBride	5652	9957	Aug. 22	May 26-June 2	July 1-8
Fraser	5655	9942	Aug. 22		
Magrath	5653	9947	Aug. 22		
Barlow	5657	9931	Aug. 23		
Numakoos	5714	9900	Aug. 18	Aug. 19	
Pine I	5656	9937	Aug. 22		
Pine II	5708	9847	Aug. 18	Aug. 19	
Lake "X"	5720	9902	Aug. 18	Aug. 19	
Hurst	5727	9945	Aug. 17		
McPherson	5723	9921	Aug. 16		
Whitefish	5534	9313	July 20	June 16-22/78	
Bearhead	5533	9610	July 20	June 23-29	
Cuddle	5525	9547	July 20	July 11-18	
Semple	5502	9538	July 26	July 19-26	
Max	5433	9558	Aug. 2	July 27-Aug.2	
Aswapiswanan	5428	9528	Aug. 9	Aug. 3-9	
Fairy Rock	5400	9545	Aug. 17	Aug. 12-17	
Willow	5357	9525	Aug. 23	Aug. 18-23	
Wass	5340	9525	Sept. 17	Sept. 8-13	
Ankle	5347	9405	Sept. 22	Sept. 19-22	

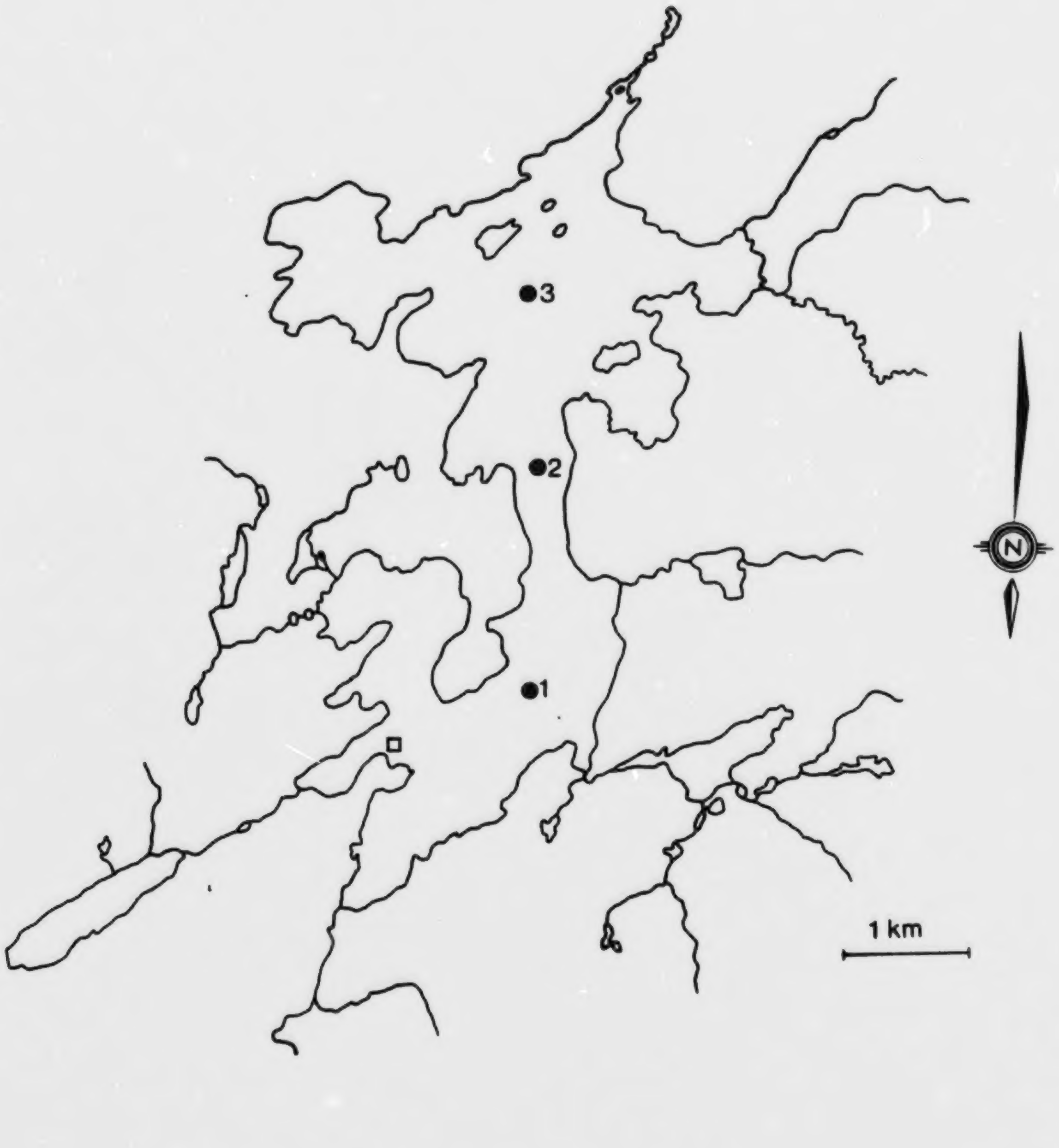

Fig. 2. Pine II Lake.

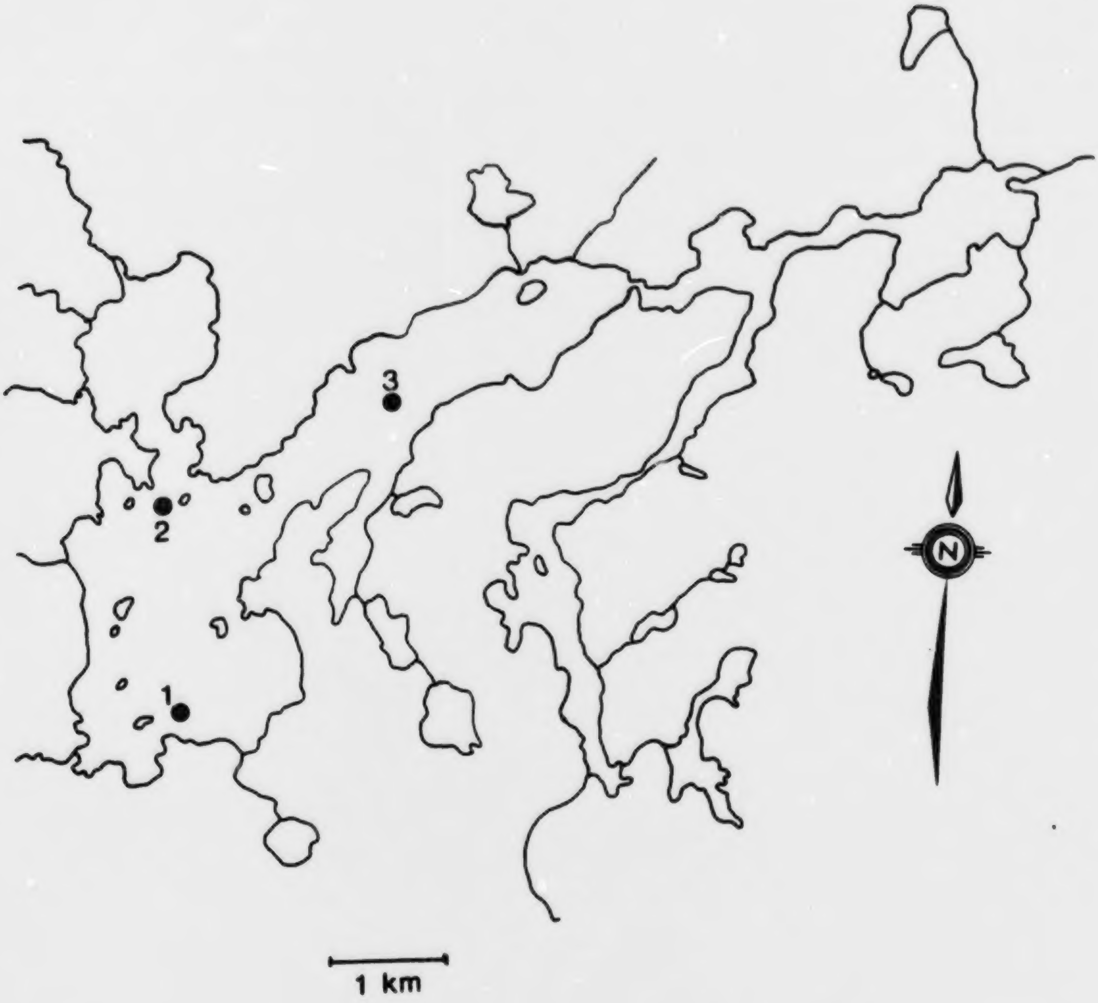

Fig. 3. Grandmother Lake.

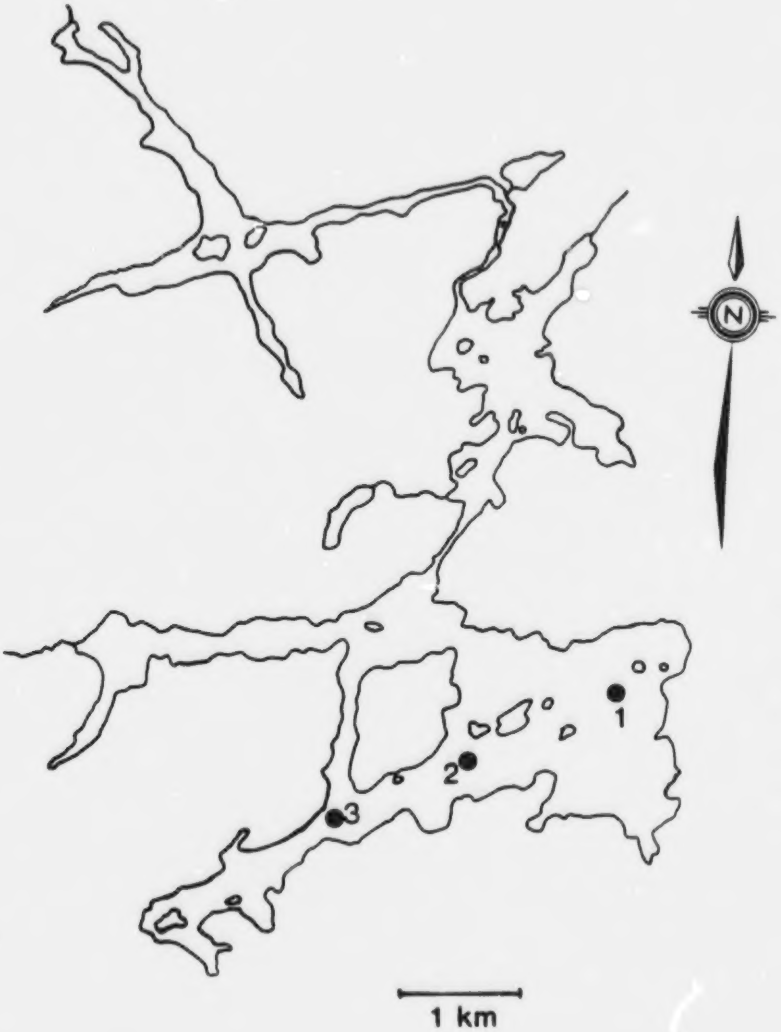

Fig. 4. Fraser Lake.

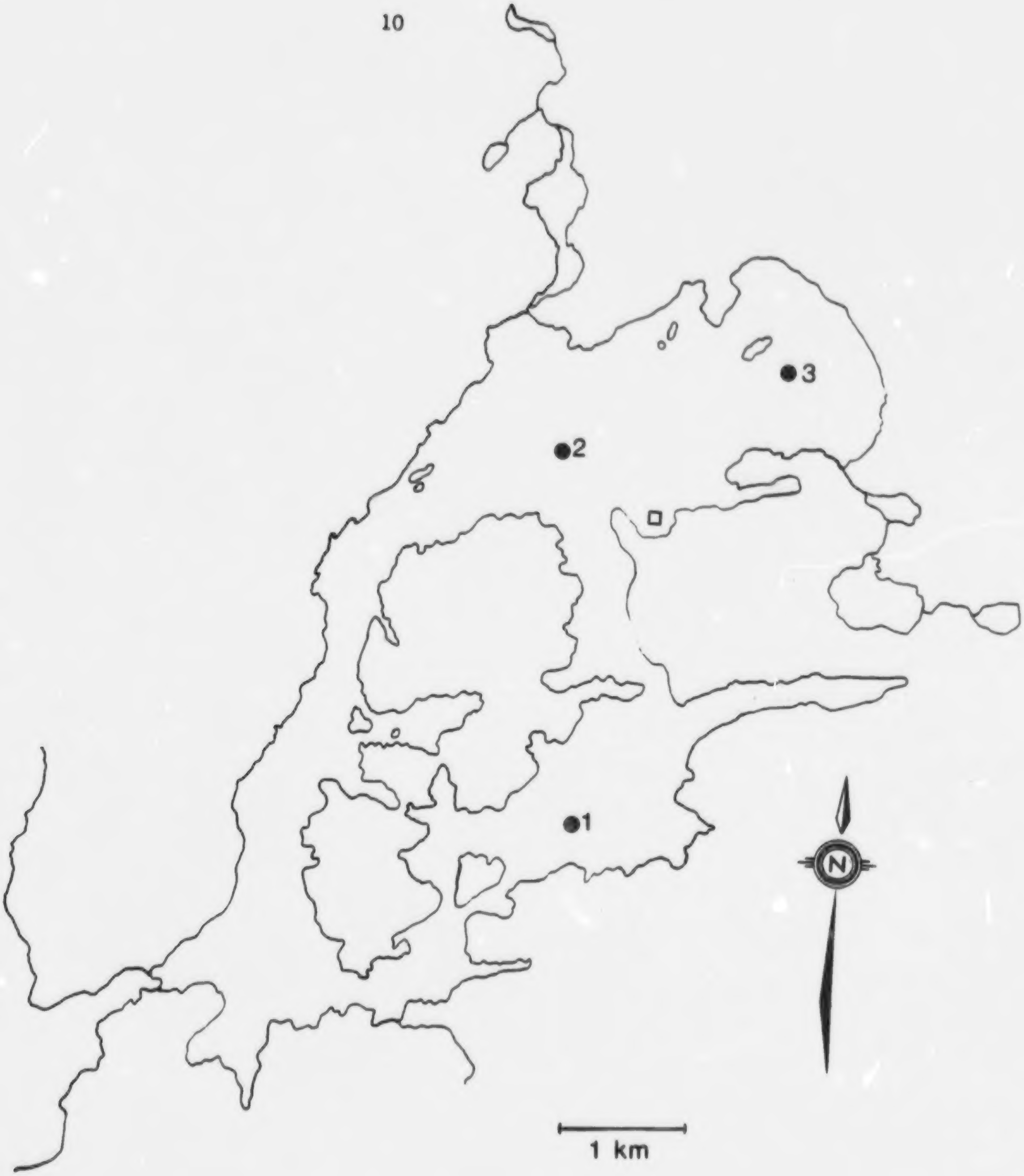

Fig. 5. James Lake.

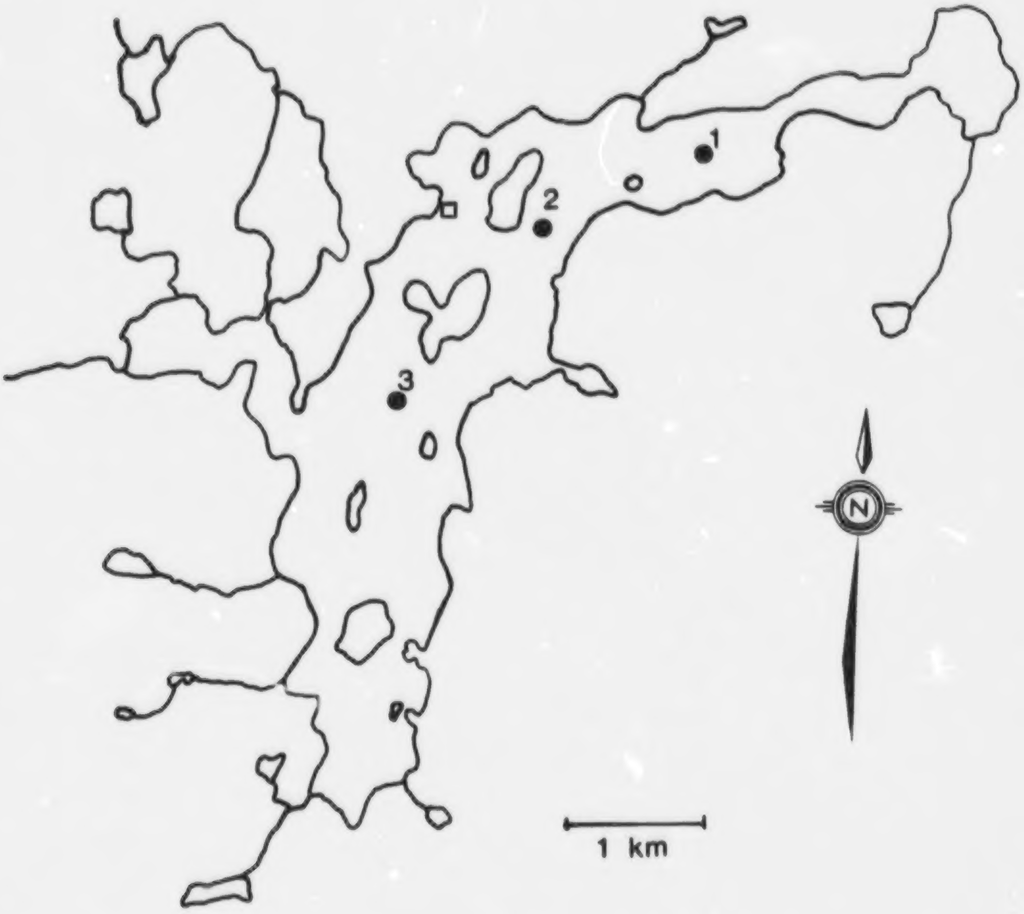

Fig. 6. McPherson Lake.

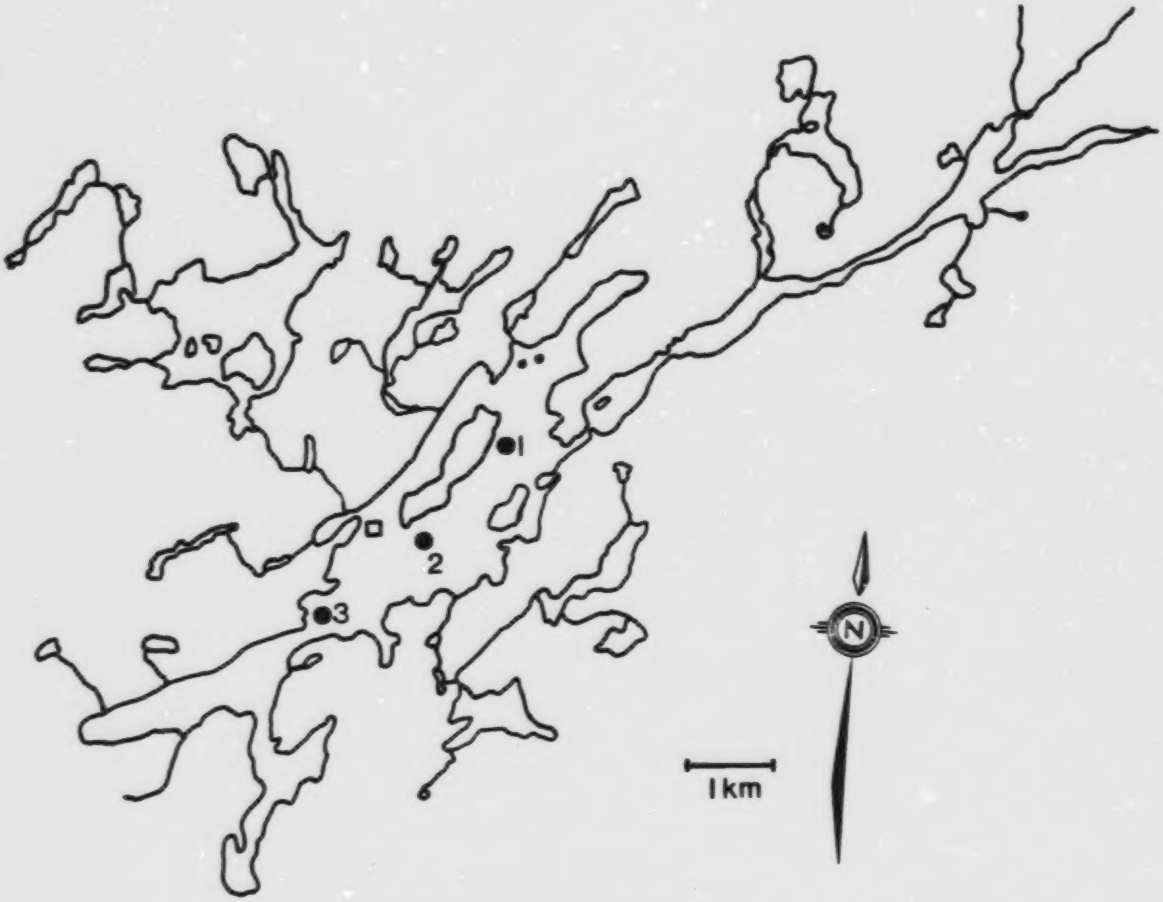

Fig. 7. Lake "X".

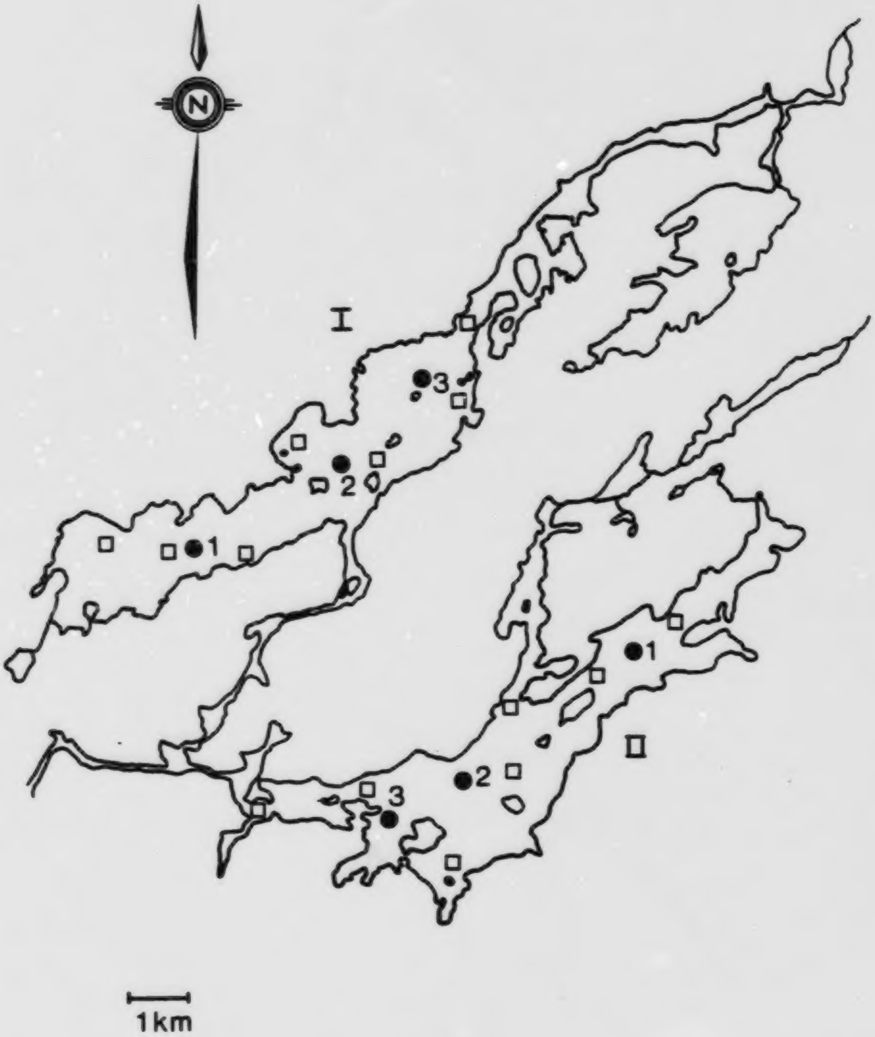
N
I
1
2
3
II
1
2
3
1km

Fig. 8. Enatik I and II Lakes.

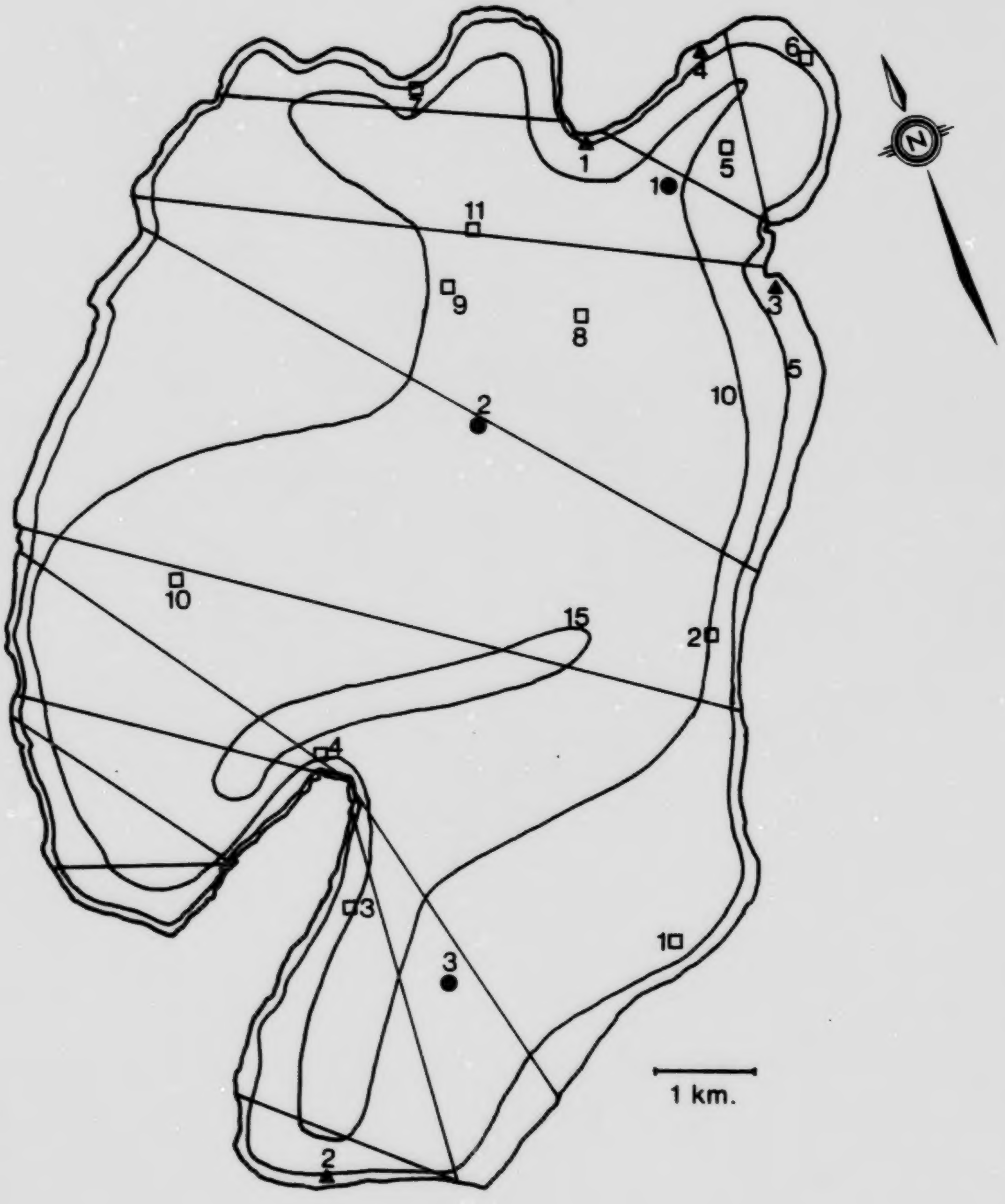
1
2
3
4
5
6
7
8
9
10
11
1●
2
3
4
5
10
15
2
10
3
10
3
2
1 km.
N

Fig. 9. Whitefish Lake. Contour interval = 5 ft.

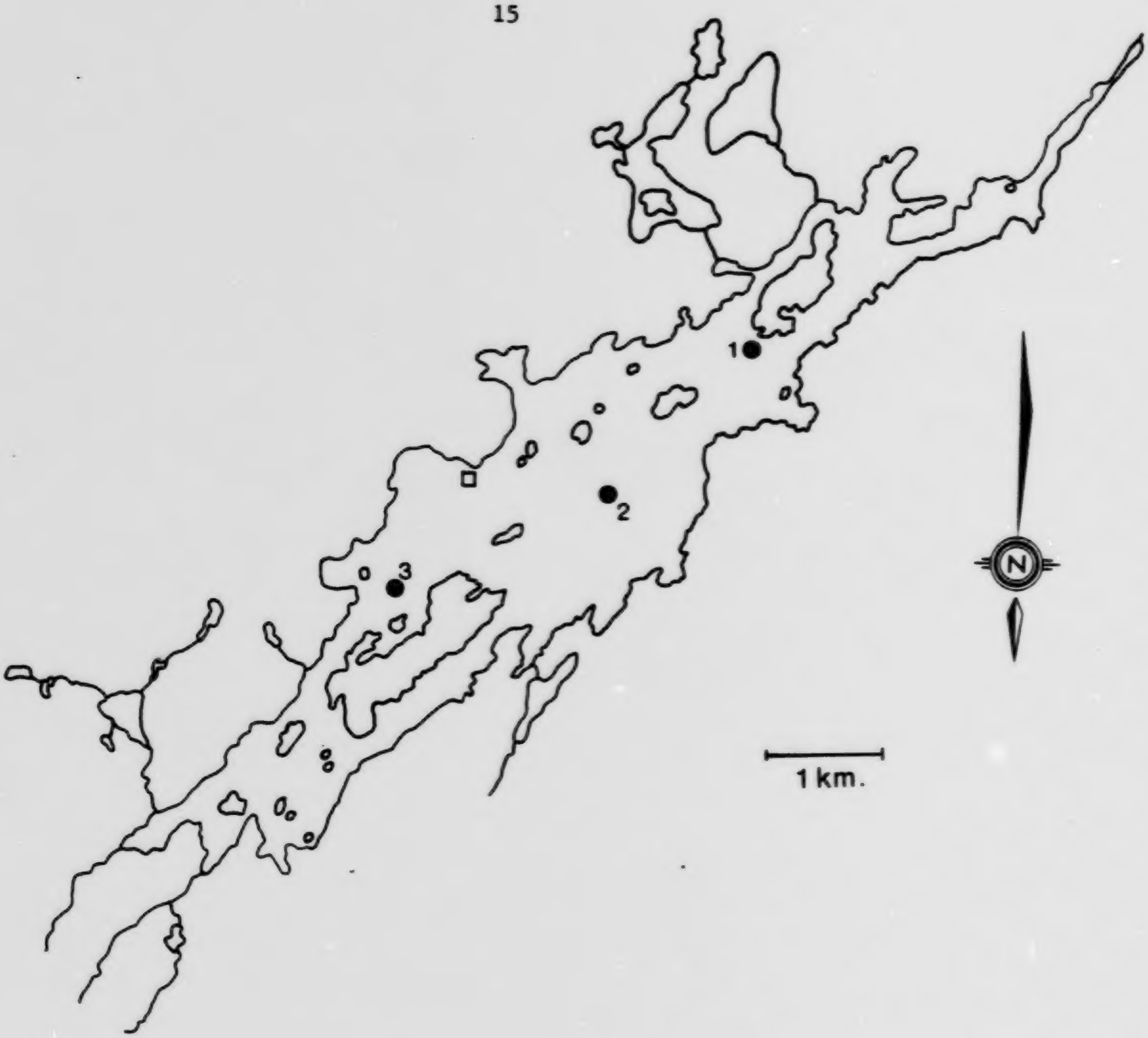

Fig. 10. Numakoos Lake.

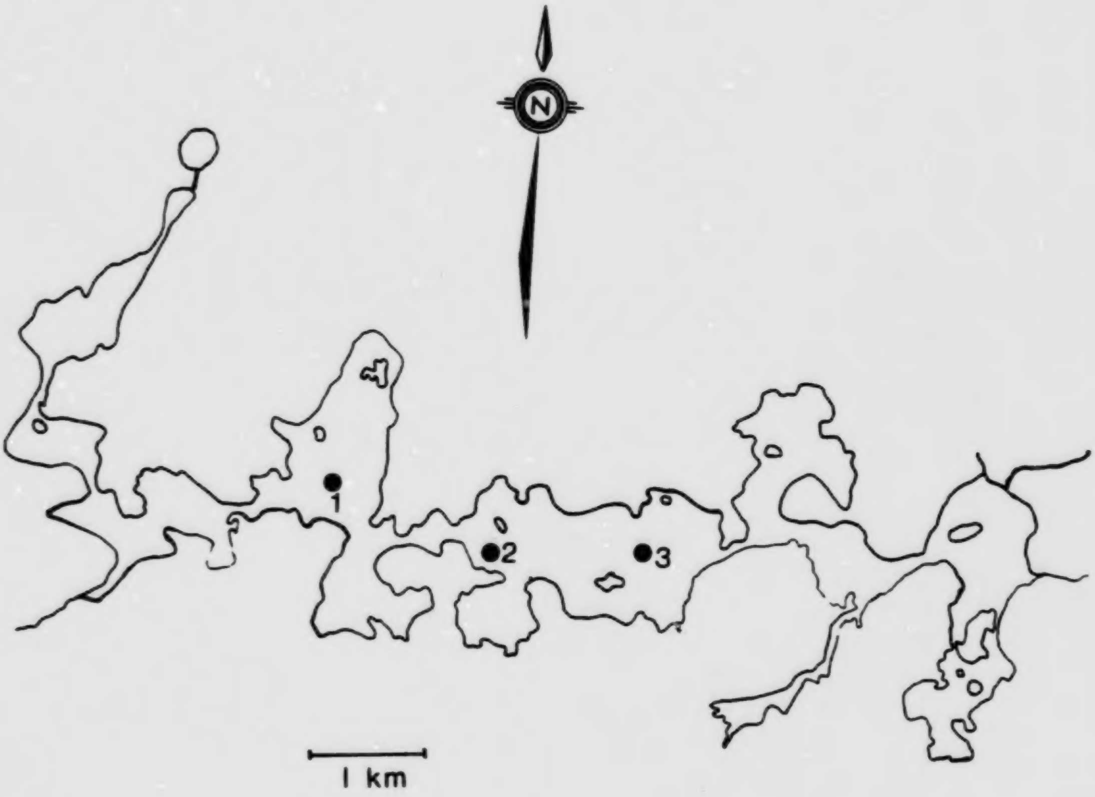

Fig. 11. Unagimau Lake.

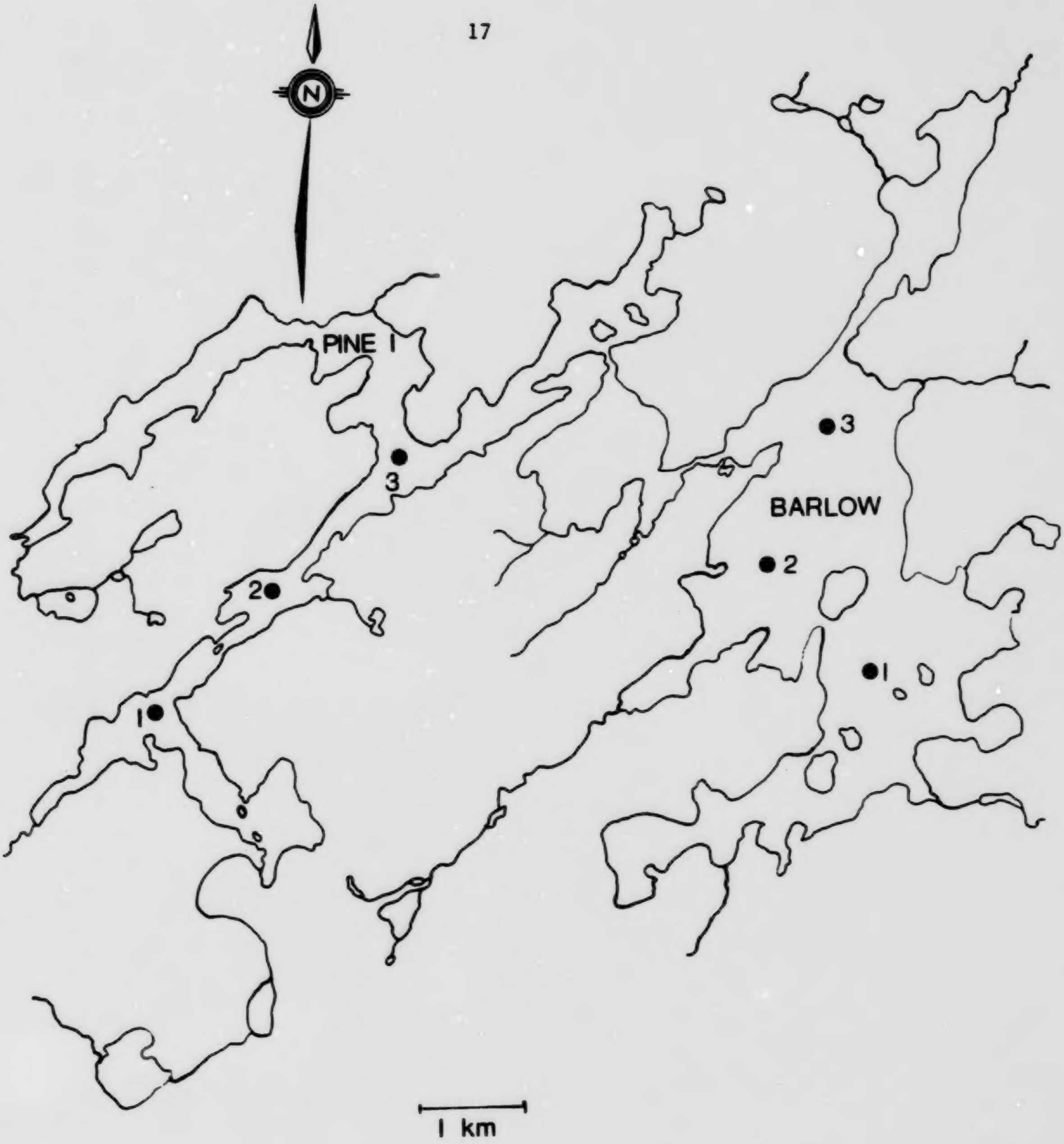
N
PINE I
3
2
1
3
BARLOW
2
1
1 km

Fig. 12. Barlow and Pine I Lakes.

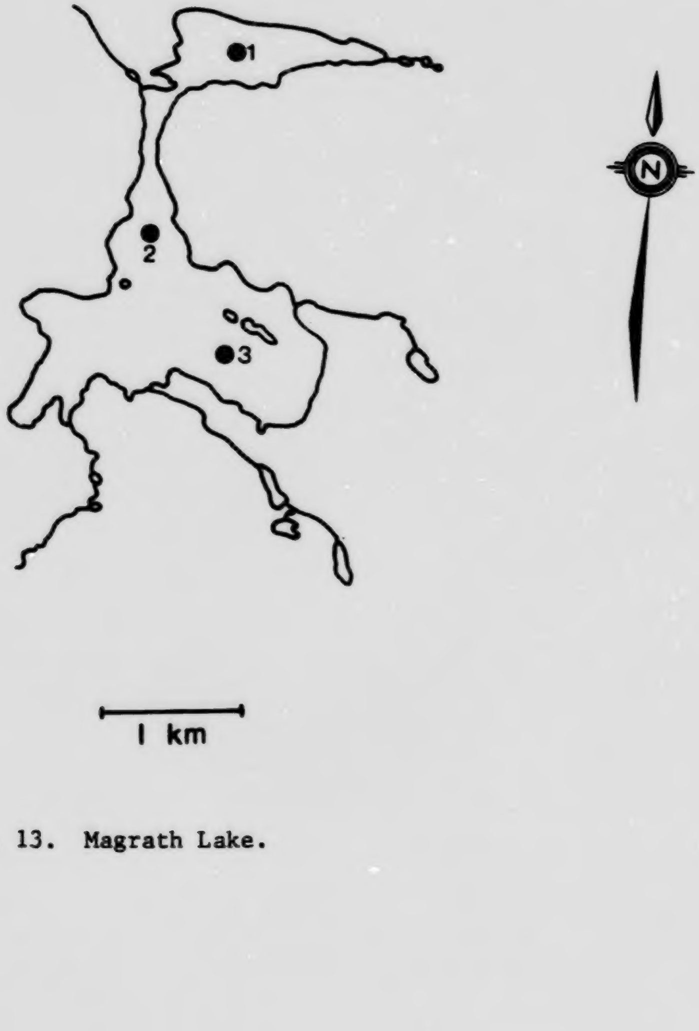

Fig. 13. Magrath Lake.

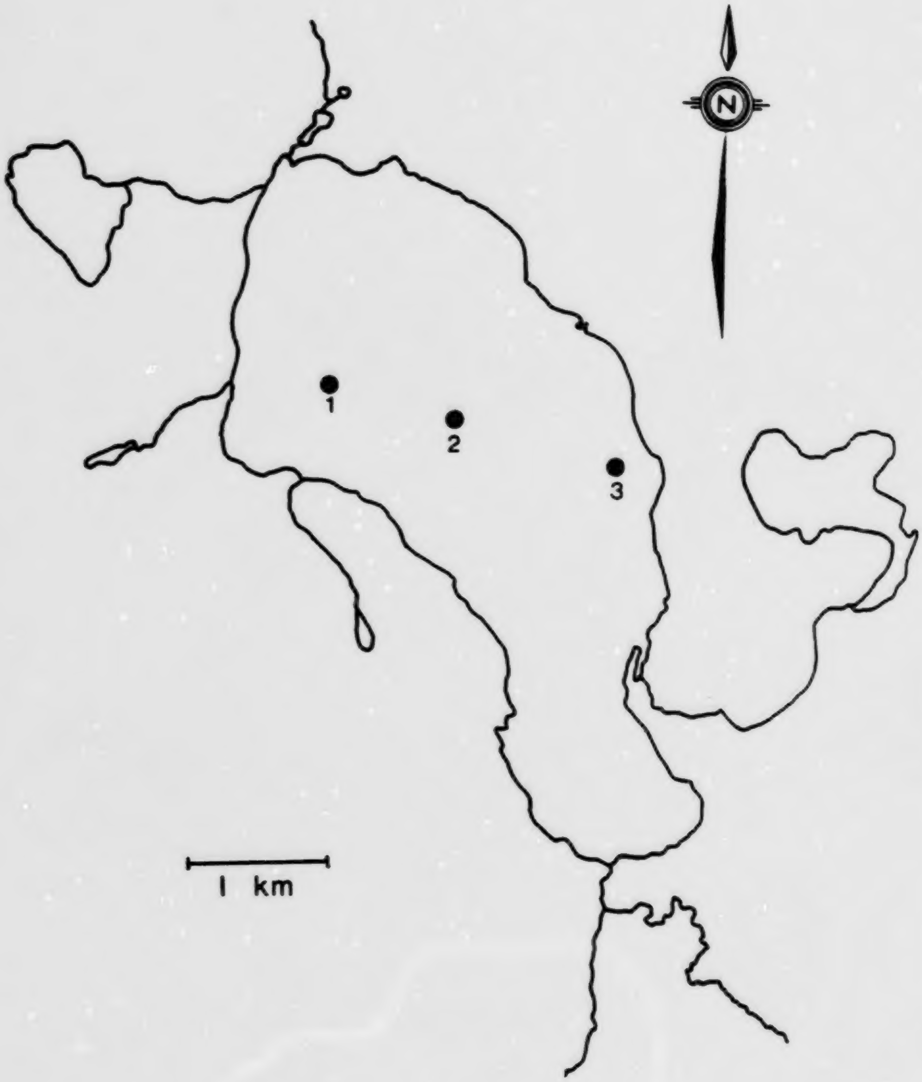

Fig. 14. Hurst Lake.

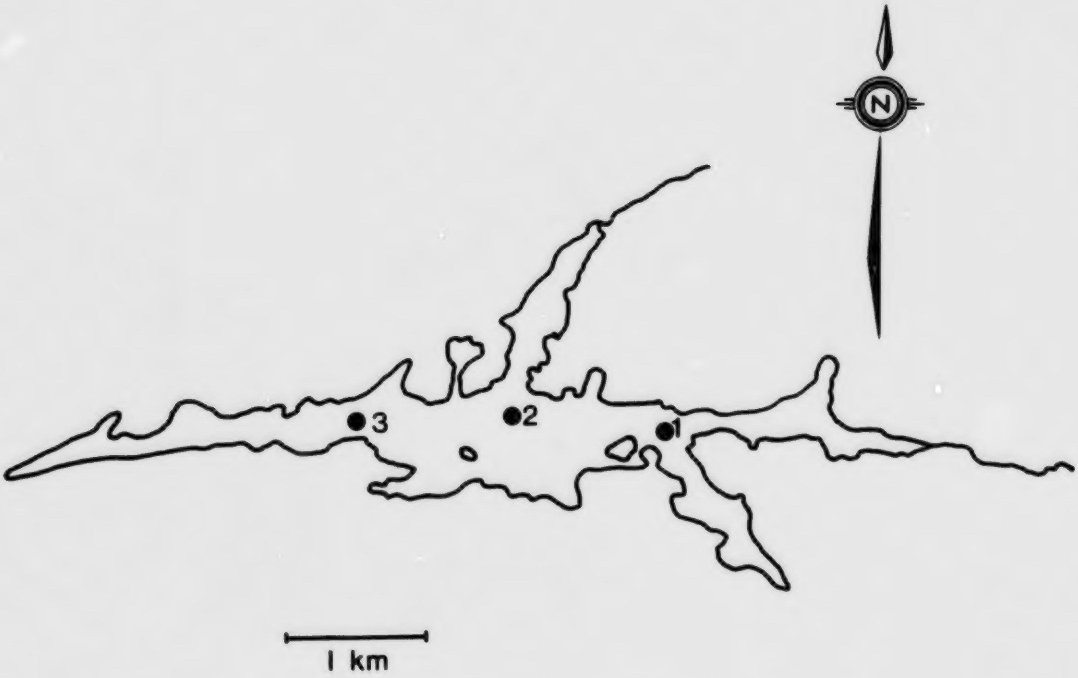

Fig. 15. McAree Lake.

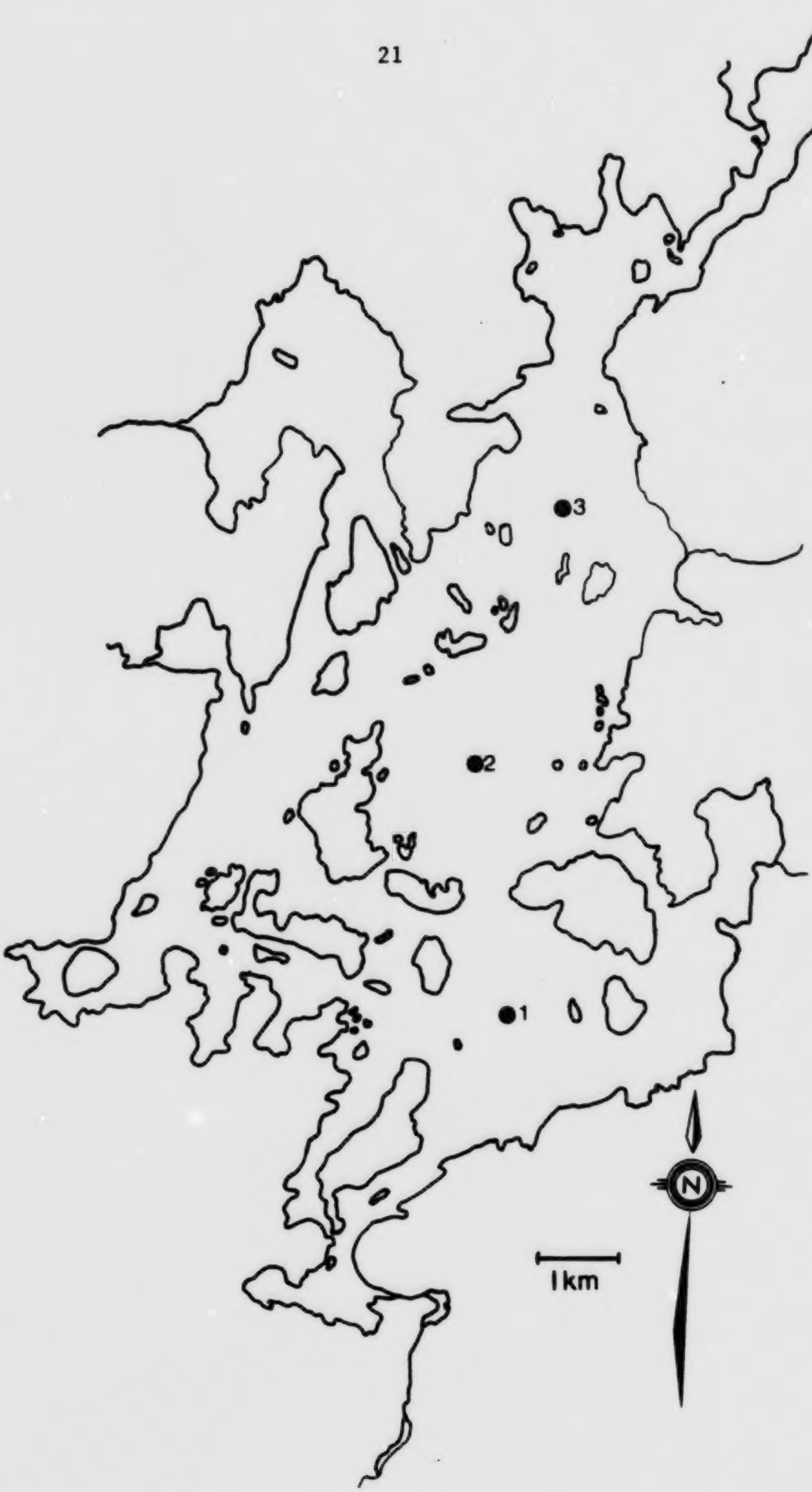

Fig. 16. Melvin Lake.

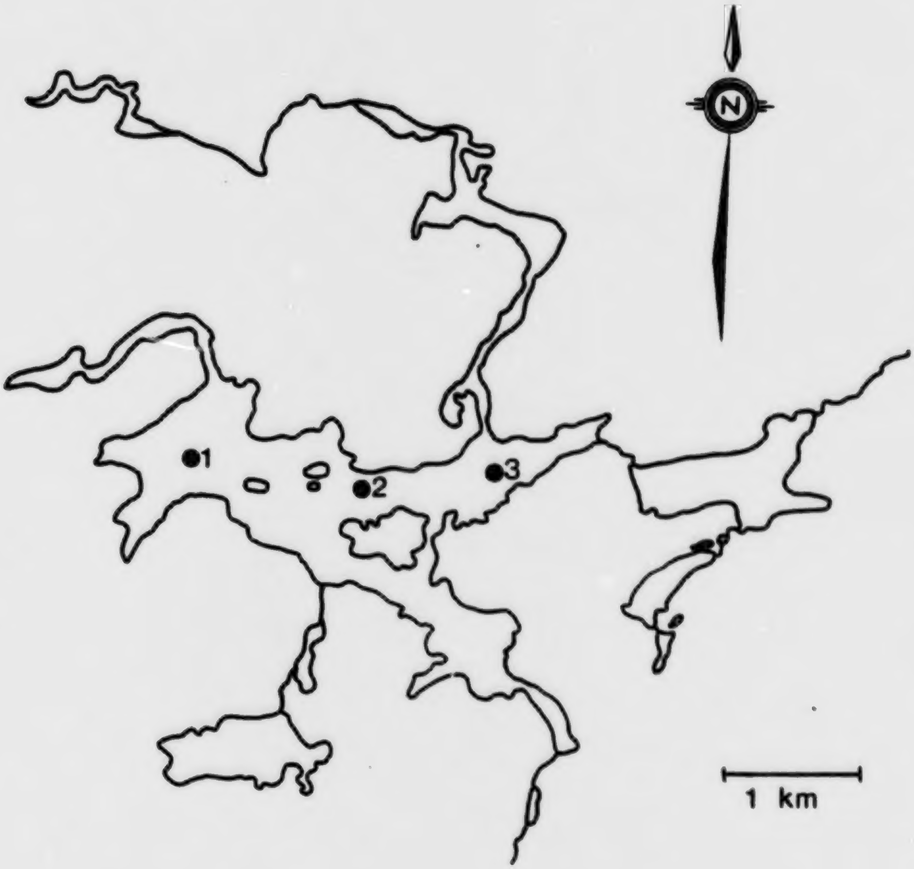

Fig. 17. McFadden Lake.

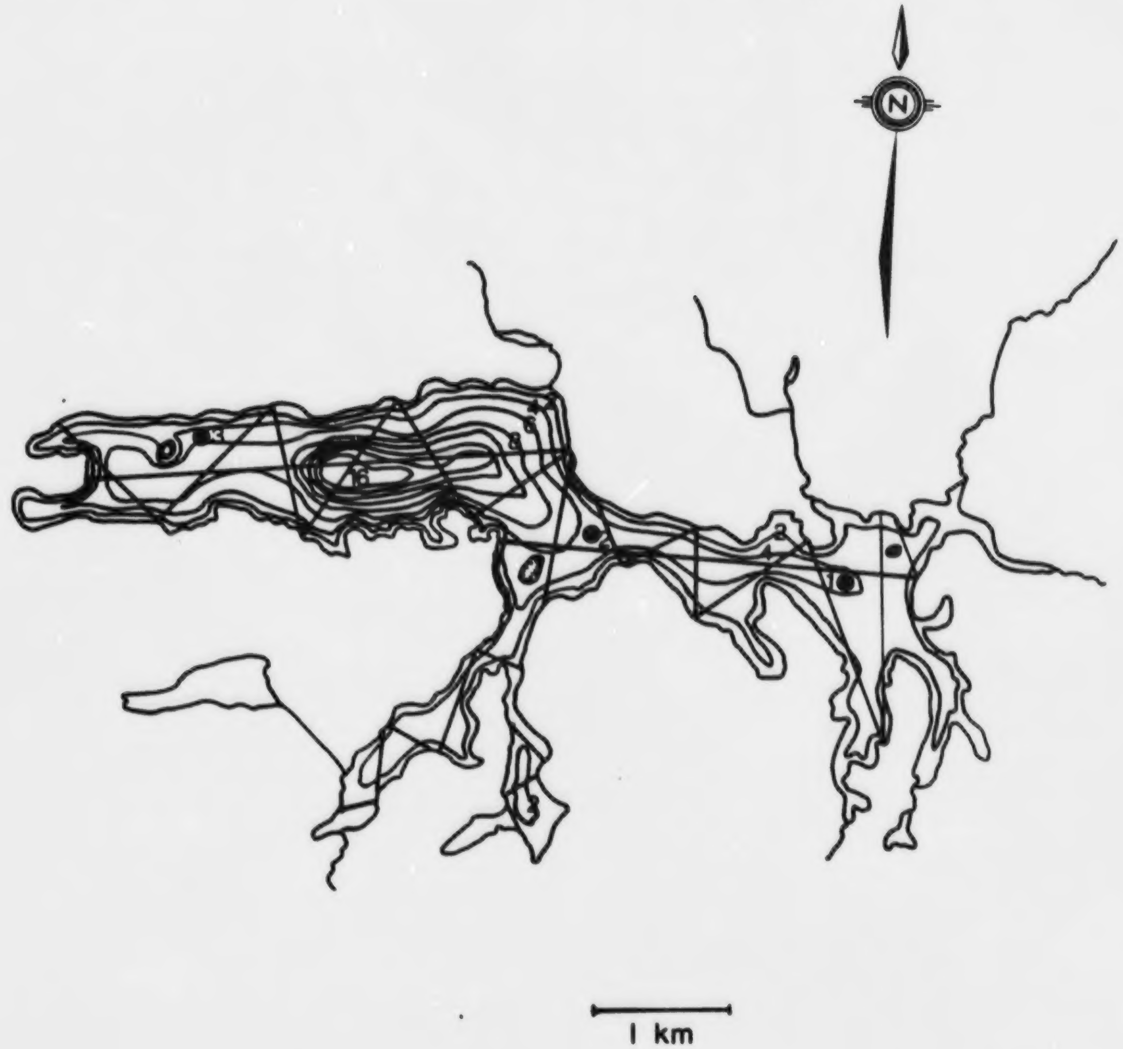

Fig. 18. MacBride Lake. Contour interval = 2m.

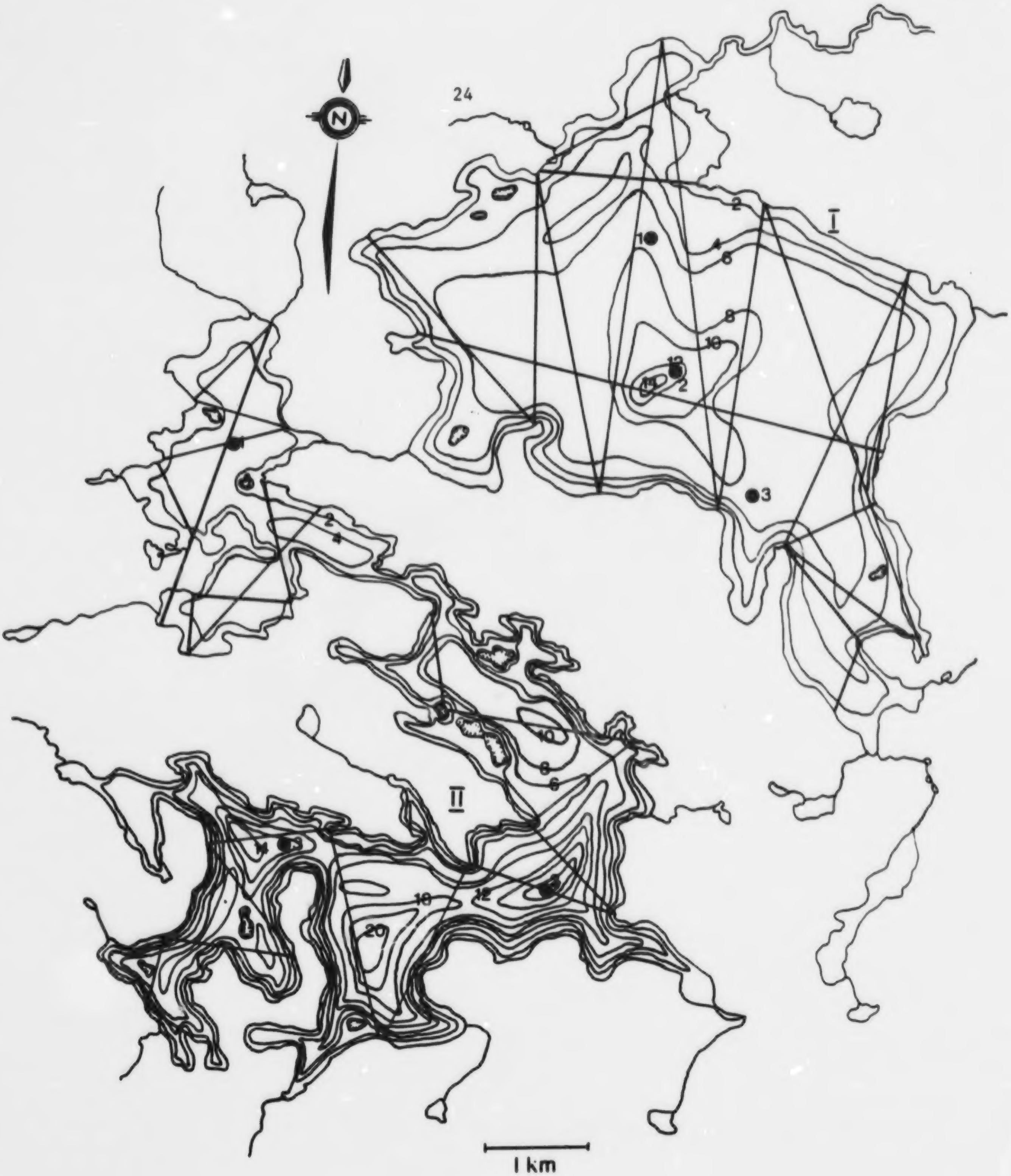
N
I
2
1
4
6
8
10
12
14
2
3
2
4
II
10
8
6
14
16
12
20
1 km

Fig. 19. MacKerracher I and II Lakes. Contour interval = 2m.

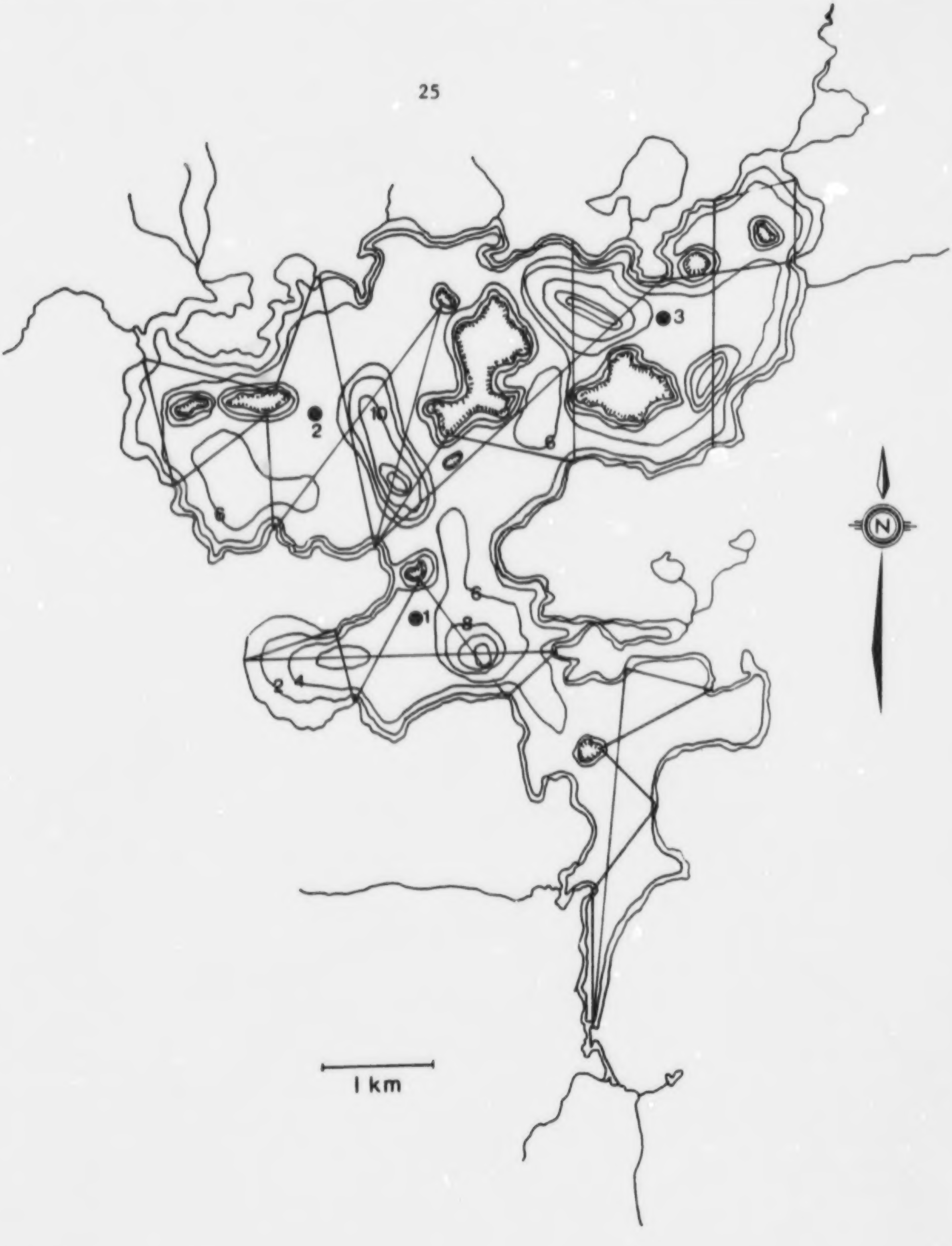
●3
●2
10
6
6
6
●1
8
2
4
N
1 km

Fig. 20. Denison Lake. Contour interval = 2m.

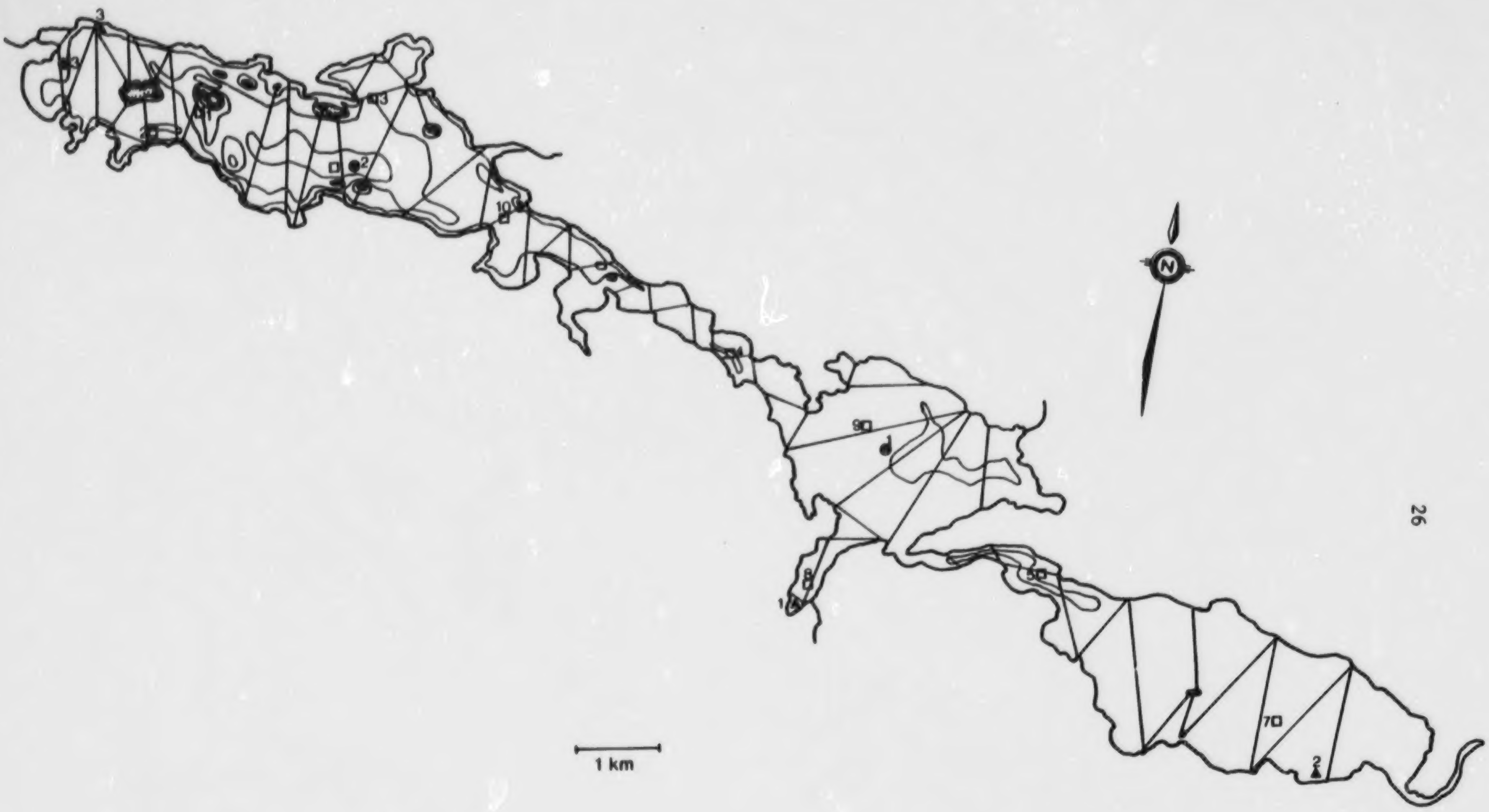
N
3
13
13
2
10
9
8
1
5
7
2
1 km

Fig. 21. Aswapiswanan Lake. Contour interval = 3m.

Table 2. Station depths.

	Depth (m)		
	Station 1	Station 2	Station 3
MacKerracher I	6	13	6
MacKerracher II	3	26	10
Denison	5	5	10
Unagimau	2	1	3
James	9	5	5
Melvin	15	9	5
Grandmother	1	1	2
Enatik I	4	8	6
Enatik II	9	5	14
McFadden	5	6	2
McAree	5	8	7
MacBride	5	4	2
Fraser	2	4	4
Magrath	12	2	3
Barlow	4	11	5
Numakoos	19	26	10
Pine I	1	1	6
Pine II	5	2	2
Lake "X"	8	5	6
Hurst	2	2	2
McPherson	3	4	3
Whitefish		3	
Bearhead		5	
Cuddle		6	
Semple		23	
Max		25	
Aswapiswanan		11	
Fairy Rock		18	
Willow		6	
Wass		17	
Ankle		23	

electronic pH meter in 1978 or a comparator kit (Hach Chemical Co., Ames, Iowa) in 1977. The conductivity of surface water at each station was measured with an electronic conductivity meter (model 33, Yellow Springs Instruments).

2.5 liters of surface water were collected at each station. A 500 ml fraction of this sample was inoculated with 1.5 ml of 50% nitric acid. Water samples were either packed in ice and analysed with 24 hours or were frozen and analysed within two weeks. The following were determined from each water sample: [Mg], [Ca], [Na], [K], total phosphorus [T.P.], [CI], [SO_4], total dissolved solids [T.D.S.], total organic carbon [T.O.C.], total inorganic carbon [T.I.C.], [NO_3 - NO_2], alkalinity, color, turbidity and hardness. Chemical analyses were performed by the Technical Services Laboratory, Man. Dept. Natural Resources.

Zooplankton and phytoplankton samples were collected with a Birge net (73 μ mesh) towed through the entire water column at one station on each lake. Littoral zooplankton was collected with a 73 μ mesh net attached to a long handle. Littoral plankters were collected at seining sites. All plankton samples were preserved in a 5% formalin solution.

One benthic sample from each lake was collected with a 6 inch x 6 inch Eckman dredge. Benthos was washed in a 400 μ mesh net and was preserved in a 5% formalin solution. Plankton and benthic samples were sorted and identified at 4X - 40X under a dissecting microscope or at 100X - 400X under a compound microscope.

Fish sampling

A 4 m x 1 m seine net (mesh size 0.635 cm) was used to collect littoral minnows. Presence or absence of aquatic macrophytes in seining sites was noted. Minnows were identified in the field. Any specimen whose identity was questionable was preserved in a 5% formalin solution and was identified later according to Scott and Crossman (1973).

Each gang of gillnets was composed of the following mesh sizes (in order): 3.81 cm. (1.5 in.), 5.08 cm. (2 in.), 7.62 cm. (3 in.), 9.525 cm. (3.75 in.), 10.795 cm. (4.25 in.) and 13.335 cm. (5.25 in.). Each net was 22.86 m (75 ft.) long and 1.22 m. (4 ft.) deep. Net orientation was reversed on alternate sets i.e., the small mesh would be nearest the shore during one set and furthest away from shore during the second set. Each gang was set for 24 hrs. Nets were set in a variety of habitat types such as shallow, vegetated sites, deep, rocky areas, sheltered and exposed areas, etc.

Walleyes, saugers, pike and whitefish caught in the gangs were processed as follows: the fork length of each fish was measured to the nearest 2 mm. Each fish was weighed to the nearest 20 gm of a Chatillon spring scale (Chatillon, Mississauga, Ont.). Six to ten scales were collected from the left side of each fish. Scales were removed above the lateral line below the anterior edge of the dorsal fin. The sex and state of maturity of each fish was visually determined by examining gonads. Otoliths and dorsal spines were collected from some *Stizostedion* sp. from each lake. Otoliths and pelvic fin rays were collected from some whitefish from each lake. Opercular bones, pelvic fin rays and cleithral bones were collected from some pike from each lake.

The mesh size that caught each walleye, sauger, pike and whitefish was recorded in 1978 but not in 1977. Numbers and weights of other fish of non-commercial species per gang were recorded.

Flesh samples from some pike were frozen and later analysed for mercury content.

To determine infestation levels of *Triaenophorus crassus,* some whitefish from each lake were measured and weighed as above. Vertical slits were cut at 0.6 - 0.9 cm intervals from the caudal peduncle to the operculum of each side of the fish. All exposed cysts were counted. The head was pressed to expose cysts hidden behind the brain.

Commercial sampling

Local fishermen were hired to commercially fish specified lakes. MacBride Lake was fished from June 1-8, 1977 by two groups of fishermen:

group 1 - W. Dysart and B. Taite
group 2 - T. Fortin and B. Fortin

Enatik I Lake was fished from June 13-20 and Enatik II Lake was fished from June 20-28, 1977 by the same fishermen that fished MacBride Lake. Denison and Mackerracher I and II Lakes were fished by three groups of fishermen:

group 1 - Ken and Ralph Spence
group 2 - John Spence and Alex Moose
group 3 - Nelson Spence and Joe Moose

Mackerracher I and II Lakes were fished from June 7 to July 20, 1977. Denison Lake was fished from July 24 to August 21, 1977. Max Lake was fished for ten days in September 1978 by Walter Skulmoski and two helpers. All fishermen were allowed to use 4.25 inch and 5.25 inch mesh nets. Fishermen kept walleyes, whitefish and pike and culled all other species such as suckers, ciscoes, perch and burbot. Daily catches and numbers of nets set were recorded on shore in the evenings.

Walleyes, saugers and whitefish were randomly selected from catches and were processed in the same manner as experimentally caught fish. Sexes and states of maturity of commercially caught fish were not determined. Only scales were collected from commercially caught fish. Individual round and dressed weights of some commercially caught fish from Denison, Mackerracher and MacBride Lakes were recorded.

Calculations

Lake volume was calculated according to the following equation:

$$\text{Lake volume} = \Sigma \text{ frustrum volumes}$$

$$\text{where frustrum volume} = \frac{h}{3} \left(a_1 + a_2 \cdot \sqrt{a_1 a_2}\right)$$

h = depth of frustrum
a_1 = area of frustrum surface
a_2 = area of frustrum bottom

Mean depth was calculated by dividing lake volume by the surface area.

Two trophic state indices (TSI) were calculated:

$$\text{TSI (SD)} = 10 \left(6 - \frac{\log_e \text{SD}}{\log_2}\right) \quad \text{(Carlson 1977)}$$

where SD = Secchi disc transparency (m)

$$\text{TDI (TP)} = 10 \left(6 - \frac{\log_e \left[\frac{48}{\overline{\text{TP}}}\right]}{\log_2}\right) \quad \text{(Carlson 1977)}$$

Morphoedaphic indices (M.E.I.) were calculated according to Ryder (1965). [T.D.S.] used in calculating the M.E.I. was the mean of three station concentrations. Potential fish yield was predicted by the following equation.

$$Y = 5.616 \; X_1^{\;0.2877} \; X_2^{\;-0.5089} \quad \text{(Ryder 1965)}$$

where Y = predicted yield (kg ha^{-1} $year^{-1}$)

X_1 = mean depth (m)

X_2 = [T.D.S.] (mg l^{-1})

Condition factors of walleyes, whitefish and pike were calculated as follows:

$$C = \frac{w \cdot 10^5}{l^3} \qquad \text{(Fulton (1911) in Ricker 1975)}$$

where w = weight (gm)

l = length (mm)

Survival rates were estimated using the complete catch curve according to Robson and Chapman (1961).

All statistical analyses were performed according to Snedecor and Cochran (1967).

RESULTS

Missing data

The pulse fishing project was terminated in 1978 before it was completed. Due to the great number of people involved, changes in personnel, relocation of all samples from one storage building to another, etc., some samples and data were mislaid or lost. The following is a list of lost samples and data:

1. counts of *Triaenophorus crassus* cysts in Denison Lake whitefish.
2. scales, and hard tissue ages of all experimentally caught fish species from Max Lake.
3. scale ages for Aswapiswanan Lake pike.
4. experimental gang numbers from Denison Lake and Enatik Lakes.
5. water chemistry data from Fairy Rock Lake.

6. all commercial samples and data from Denison Lake and the Mackerracher Lakes.
7. otoliths of Ankle Lake whitefish.
8. Seined fish species from lakes surveyed in 1977.

Limnological sampling

Volumes, surface areas and mean depths of depth-sounded lakes ranged from 33448085 m^3 to 165956187 m^3, from 7807236 m^2 to 57159100 m^2 and from 1.55 m to 14.07 m, respectively (Table 3). Seven of the fourteen lakes had mean depths shallower than 5m.

Mackerracher II and Numakoos were the only lakes that showed evidence of thermal stratification in 1977 while Fairy Rock, Ankle and Max Lakes were thermally stratified and Semple Lake showed some evidence of thermal stratification in 1978 (Appendix A).

The Secchi disc transparency values and phosphorus concentrations used in calculating the two trophic state indices for each lake were the means of three station values. Mean transparency ranged from 0.75 m in Grandmother Lake to 3.1 m in Max Lake. Mean [P] ranged from <20 mg m^{-3} in six of the lakes to 80 mg m^{-3} in Willow Lake (Table 4).

Conductivity values ranged from 35.4 μmho cm^{-1} on Melvin Lake to 124 μmho cm^{-1} on Aswapiswanan Lake. Filterable residue, [T.D.S.], ranged from 12 mg l^{-1} on Melvin Lake to 122 mg l^{-1} on Pine I Lake (Table 5). pH ranged from 7.25 on Melvin Lake to 9.2 on Whitefish Lake (Table 6). Color, turbidity and concentrations of Ca, Mg, $CaCO_3$, Fe, K, Na, Cl, SO_4, T.O.C., T.I.C., NO_2 - NO_3 and P are listed in Appendix B.

Species composition of phytoplankton, zooplankton, and some benthos are listed in Appendix C. Work is continuing on benthic identification.

Table 3. Morphometry, morphoedaphic indices and predicted yields of depth-sounded lakes.

Lake	Volume (m^3)	Surface area (m^2)	Mean depth (m)	Mean [T.D.S.] (mg l^{-1})	M.E.I.	Predicted yield	
						kg ha^{-1}	Total lake
Denison	115271963	23802952	4.84	41.3	8.53	3.82	9093
MackerracherI	102796999	19808167	5.19	58.3	11.23	4.36	8636
MackerracherII	88013073	16774783	5.25	43.0	8.19	3.75	6291
MacBride	33448085	7807236	4.28	80.3	18.76	5.56	4341
Semple	61118653	39502128	1.55	78.7	50.77	8.91	35196
Bearhead	39941454	19158900	2.08	77.0	37.02	7.67	14695
Aswapiswanan	91385078	32634140	2.80	77.3	27.61	6.68	21800
Ankle	56927386	8023278	7.10	50.3	7.08	3.50	2808
Wass	133284851	29972700	4.45	83.7	18.81	5.56	16665
Willow	116224214	8259827	14.07	71.7	5.10	2.99	2470
Fairy Rock	121980632	18625426	6.55	89.0	15.12	5.02	9350
Whitefish	165956187	57159100	2.90	62.3	21.48	5.93	33895
Max	80592912	18330900	4.40	62.7	14.25	4.88	8945
Cuddle	197337758	25318197	7.79	73.0	9.37	4.00	10127

Table 4 . Trophic state indices of surveyed lakes.

Lake	Mean transparency (m)	Mean P concentration (mg m $^{-3}$)	TSI(SD)	TSI(TP)
James	2.5	20	46.8	47.4
Hurst	2	23.3	50	49.6
Unagimau	1.75	20	51.9	47.4
MacKerracher I	1.83	20	51.3	47.4
MacKerracher II	2	30	50	53.2
Pine I	.92	40	61.2	57.4
Pine II	1.5	20	54.2	47.4
Numakoos	2.42	20	47.2	47.4
Lake X	2.17	20	48.8	47.4
Grandmother	.75	30	64.2	53.2
Barlow	1.3	33.3	56.2	54.7
Fraser	1.42	20	54.9	47.4
Enatik I	1.33	19.3	55.9	46.9
Enatik II	1.5	23.3	54.2	49.6
Melvin	1.58	20	53.4	47.4
McAree	1.83	20	51.3	47.4
MacBride	1.08	20	58.9	47.4
Magrath	1.67	26.6	52.6	51.5
McFadden	1.08	26.6	58.9	51.5
Denison	2	26.6	50	51.5
MacPherson	2	56.6	50	62.4
Whitefish	2.4	<20	<47.2	<47.4
Bearhead	1.6	37	53.2	56.2
Cuddle	1.7	<20	52.3	<47.4
Semple	1.7	<20	53.3	<47.4
Max	3.1	<20	43.7	<47.4
Aswapiswanan	2.3	<20	48.0	<47.4
Fairy Rock	1.7	-	52.7	-
Willow	1.5	80	54.2	67.4
Wass	1.8	30	51.5	53.2
Ankle	2.3	<20	48.0	<47.4

Table 5 . Conductivity and residue of surveyed lakes.

Lake	Station	Conductivity (µmho cm^{-1})	Residue ($mg\ l^{-1}$) Total	Filterable	Non-Filterable
James	1	37.6	44.0	44.0	L 5.0
	2	38.8	38.0	38.0	L 5.0
	3	49.2	39.0	34.0	5.0
Hurst	1	70.6	64.0	64.0	L 5.0
	2	69.1	60.0	60.0	L 5.0
	3	70.6	68.0	62.0	6.0
Unagimau	1	38.5	54.0	54.0	L 5.0
	2	36.2	44.0	44.0	L 5.0
	3	35.6	60.0	60.0	L 5.0
MacKerracher I	1	85.5	56.0	56.0	L 5.0
	2	84.8	64.0	59.0	5.0
	3	82.6	60.0	60.0	L 5.0
MacKerracher II	1	117.0	44.0	36.0	8.0
	2	92.4	50.0	40.0	10.0
	3	92.4	62.0	53.0	9.0
Pine II	1	71.4	72.0	72.0	L 5.0
	2	69.3	78.0	78.0	L 5.0
	3	69.3	56.0	50.0	6.0
Numakoos	1	93.4	70.0	70.0	L 5.0
	2	95.2	72.0	67.0	5.0
	3	91.5	84.0	79.0	5.0
Lake X	1	107.0	76.0	71.0	5.0
	2	107.0	76.0	64.0	12.0
	3	106.0	78.0	65.0	13.0
Grandmother	1	62.5	78.0	65.0	13.0
	2	65.5	78.0	66.0	12.0
	3	60.9	74.0	59.0	15.0
Barlow	1	102.0	92.0	92.0	L 5.0
	2	104.0	70.0	64.0	6.0
	3	105.0	80.0	72.0	8.0
Pine I	1	97.4	104.0	95.0	9.0
	2	101.0	94.0	89.0	5.0
	3	96.4	122.0	122.0	L 5.0
Fraser	1	80.5	66.0	59.0	7.0
	2	80.0	56.0	49.0	7.0
	3	80.5	58.0	51.0	7.0

Enatik I	1	81.6	72.0	72.0	L 5.0
	2	64.9	50.0	50.0	L 5.0
	3	64.9	40.0	40.0	L 5.0
Enatik II	1	82.6	40.0	33.0	7.0
	2	80.5	30.0	21.0	9.0
	3	79.1	54.0	46.0	8.0
Melvin	1	36.6	18.0	12.0	6.0
	2	37.1	24.0	16.0	8.0
	3	35.4	26.0	26.0	L 5.0
McAree	1	73.8	30.0	30.0	L 5.0
	2	73.8	22.0	15.0	7.0
	3	70.8	80.0	74.0	6.0
MacBride	1	67.8	84.0	84.0	L 5.0
	2	69.0	88.0	83.0	5.0
	3	67.8	82.0	74.0	8.0
Magrath	1	79.8	108.0	101.0	7.0
	2	83.3	104.0	98.0	6.0
	3	83.3	106.0	100.0	6.0
McFadden	1	76.7	84.0	84.0	L 5.0
	2	70.8	84.0	77.0	7.0
	3	74.8	86.0	86.0	L 5.0
Denison	1	86.8	34.0	34.0	5.0
	2	86.8	48.0	41.0	7.0
	3	86.8	54.0	49.0	5.0
MacPherson	1	94.5	68.0	54.0	14.0
	2	95.9	62.0	51.0	11.0
	3	93.5	70.0	62.0	8.0
Whitefish	1	105	106	84	22
	2	70.8	70	56	24
	3	85.6	86	47	39
Bearhead	1	68.4	78	62	16
	2	94.8	100	93	7
	3	86.3	92	76	16
Cuddle	1	88.5	88	79	9
	2	94.4	84	76	8
	3	74.3	88	64	24
Semple	1	78.4	96	83	13
	2	92.1	88	71	11
	3	92.7	92	82	10

Max	1	82.5	82	69	13
	2	76.6	78	60	18
	3	93.2	78	59	19
Aswapiswanan	1	86.4	80	67	13
	2	93.1	76	70	6
	3	124	114	95	19
Willow	1	108	92	83	9
	2	113	74	64	10
	3	88.1	76	68	8
Wass	1	88.5	98	81	17
	2	84.4	104	86	18
	3	92	104	84	20
Ankle	1	59.5	60	47	13
	2	73.2	68	57	11
	3	62.5	56	47	9

Table 6. Alkalinity and pH of surveyed lakes.

Lake	Station	Alkalinity (mg l^{-1})				pH
		Total ($CaCO_3$)	HCO_3	CO_3	OH	
James	1	16.0	19.5	0	0	7.30
	2	16.0	19.5	0	0	7.35
	3	24.0	29.2	0	0	7.35
Hurst	1	34.0	41.5	0	0	7.70
	2	32.0	39.0	0	0	7.65
	3	32.0	39.0	0	0	7.70
Unagimau	1	18.0	22.0	0	0	7.35
	2	18.0	22.0	0	0	7.40
	3	16.0	19.5	0	0	7.30
MacKerracher I	1	44.0	53.7	0	0	7.95
	2	40.0	48.0	0	0	7.85
	3	44.0	53.7	0	0	7.90
MacKerracher II	1	44.0	53.7	0	0	7.90
	2	44.0	53.7	0	0	7.80
	3	46.0	56.1	0	0	7.80
Pine II	1	32.0	39.0	0	0	7.45
	2	30.0	39.0	0	0	7.50
	3	34.0	41.5	0	0	7.50
Numakoos	1	32.0	39.0	0	0	7.60
	2	46.0	56.1	0	0	7.90
	3	44.0	53.7	0	0	7.80
Lake X	1	54.0	65.9	0	0	7.90
	2	54.0	65.9	0	0	7.95
	3	50.0	61.0	0	0	7.85
Grandmother	1	30.0	36.5	0	0	7.60
	2	32.0	39.0	0	0	7.60
	3	28.0	34.2	0	0	7.50
Barlow	1	48.0	53.7	2.4	0	8.60
	2	48.0	53.7	2.4	0	8.60
	3	48.0	53.7	2.4	0	8.55
Pine I	1	50.0	51.2	4.80	0	8.90
	2	48.0	48.8	4.80	0	8.90
	3	48.0	48.8	4.80	0	8.90

Fraser	1	38.0	46.4	0	0	7.70
	2	40.0	48.8	0	0	7.60
	3	36.0	43.9	0	0	7.70
Enatik I	1	34.0	41.5	0	0	7.60
	2	30.0	36.6	0	0	7.60
	3	30.0	36.6	0	0	7.70
Enatik II	1	38.0	46.4	0	0	7.80
	2	40.0	48.8	0	0	7.80
	3	40.0	48.8	0	0	7.90
Melvin	1	14.0	17.1	0	0	7.25
	2	18.0	22.0	0	0	7.30
	3	16.0	19.5	0	0	7.30
McAree	1	44.0	53.7	0	0	7.80
	2	36.0	43.9	0	0	7.80
	3	32.0	39.0	0	0	7.75
MacBride	1	30.0	36.6	0	0	7.75
	2	32.0	39.0	0	0	7.70
	3	32.0	39.0	0	0	7.70
Magrath	1	38.0	46.4	0	0	7.80
	2	38.0	46.4	0	0	7.85
	3	40.0	48.8	0	0	7.90
McFadden	1	32.0	39.0	0	0	7.65
	2	36.0	43.9	0	0	7.70
	3	34.0	41.5	0	0	7.70
Denison	1	42.0	51.2	0	0	7.85
	2	38.0	46.4	0	0	7.80
	3	40.0	48.8	0	0	7.80
MacPherson	1	44.0	53.7	0	0	7.90
	2	46.0	56.1	0	0	7.90
	3	46.0	56.1	0	0	7.90
Whitefish	1	-	-	-	-	9.2
	2	-	-	-	-	9.2
	3	-	-	-	-	9.2
Bearhead	1	-	-	-	-	8.7
	2	-	-	-	-	8.7
	3	-	-	-	-	8.7
Cuddle	1	-	-	-	-	8.8
	2	-	-	-	-	8.8
	3	-	-	-	-	8.8

Semple	1	39.0	35.4	6.0	0	8.9
	2	43.0	47.6	2.4	0	8.8
	3	44.0	40.0	6.7	0	8.7
Max	1	42.0	39.0	6.0	0	8.0
	2	36.0	26.8	8.4	0	8.0
	3	44.0	39.0	7.2	0	8.0
Aswapiswanan	1	43.0	38.8	6.7	0	8.8
	2	44.6	32.5	10.8	0	9.0
	3	63.0	62.2	7.2	0	8.8
Fairy Rock	1	-	-	-	-	9.0
	2	-	-	-	-	9.0
	3	-	-	-	-	9.0
Willow	1	52.0	63.4	0	0	8.3
	2	49.0	59.8	0	0	8.3
	3	44.0	48.8	2.4	0	8.6
Wass	1	-	-	-	-	8.6
	2	-	-	-	-	8.5
	3	-	-	-	-	8.5
Ankle	1	-	-	-	-	8.0
	2	-	-	-	-	8.0
	3	-	-	-	-	8.0

Fish sampling

Cyprinids and juvenile fish caught with seines in 1978 are listed in Appendix D.

From the 14 lakes in which more than 1 gang of gillnets was set, 13 contained populations of walleyes and whitefish. All surveyed lakes contained pike populations. Ankle Lake was the only lake in which white suckers were not netted but longnose suckers were present. Walleyes comprised a major portion of the catches from Wass and Willow Lakes. Proportions of pike were concomitantly lowest in Wass and Willow Lakes. Saugers were present at very low levels in Aswapiswanan, Wass and Willow Lakes. Two lake trout were captured in Numakoos Lake. One to three burbots were caught in MacBride, Semple, Max and Wass Lakes (Table 7).

Pine II Lake was the only lake surveyed in 1977 that contained an export quality population of whitefish (<40 cysts cwt^{-1}). James, MacBride and the Mackerracher Lakes contained cutter quality (80 + cysts cwt^{-1}) whitefish populations (Table 8). In 1978, four of the ten surveyed lakes contained export quality whitefish (Table 9).

Regression of mercury content and body size of pike and walleyes were significant in most of the lakes from which more than ten pike and walleyes were collected (Table 10).

The following analyses of walleye, whitefish and pike growth regimes were performed on age-specific mean lengths and weights (Table 11).

All age-specific mean lengths-weight regressions were significant excepting that of McPherson Lake whitefish (Table 12).

Table 7. Species composition determined from gillnet catches.

Lake	Species											Total no. fish
	walleye	whitefish	pike	perch	cisco	white sucker	longnose sucker	redhorse sucker	burbot	lake trout	sauger	
1977												
Denison												
no.	214	235	140	54	5	169	12	0	0	0	0	829
%	25.8	28.3	16.9	6.5	0.6	20.4	1.4	-	-	-	-	
Mackerracher I												
no.	145	208	192	1	0	137	42	0	0	0	0	725
%	20.0	28.7	26.5	0.1	-	18.9	5.8	-	-	-	-	
Mackerracher II												
no.	64	114	121	9	8	141	12	0	0	0	0	469
%	13.6	24.3	25.8	1.9	1.7	30.1	2.6	-	-	-	-	
MacBride												
no.	140	119	270	23	193	45	0	0	3	0	0	793
%	17.7	15.0	34.0	2.9	24.3	5.7	-	-	0.4	-	-	
Pine II												
no.	0	19	19	1	0	14	0	0	0	0	0	53
%	-	35.8	35.8	1.9	-	26.4	-	-	-	-	-	
Numakoos												
no.	0	19	19	0	0	37	0	0	0	2	0	77
%	-	24.7	24.7	-	-	48.1	-	-	-	2.6	-	
James												
no.	0	29	15	0	0	0	0	0	0	0	0	44
%	-	65.9	34.1	-	-	-	-	-	-	-	-	
Lake X												
no.	14	4	10	0	2	11	0	0	0	0	0	41
%	34.1	9.8	24.4	-	4.9	26.8	-	-	-	-	-	
McPherson												
no.	0	55	10	0	0	0	0	0	0	0	0	65
%	-	84.6	15.4	-	-	-	-	-	-	-	-	

1978											
Bearhead											
no.	106	42	138	12	126	252	0	0	0	0	0	676
%	15.7	6.2	20.4	1.8	18.6	37.3	-	-	-	-	-	
Cuddle												
no.	89	26	106	17	8.	343	0	0	0	0	0	589
%	15.1	4.4	18.0	2.9	1.4	58.2	-	-	-	-	-	
Semple												
no.	66	245	49	5	6	180	0	0	1	0	0	552
%	12.0	44.4	8.9	0.9	1.1	32.6	-	-	0.2	-	-	
Ankle												
no.	95	66	53	7	188	0	18	0	0	0	0	427
%	22.3	15.5	12.4	1.6	44.0	-	4.2	-	-	-	-	
Max												
no.	45	91	43	30	276	32	0	1	2	0	0	520
%	8.7	17.5	8.3	5.8	53.1	6.2	0	0.2	0.4	-	-	
Aswapiswanan												
no.	136	88	75	38	92	60	0	0	0	0	9	498
%	27.3	17.7	15.1	7.6	18.5	12.1	-	-	-	-	1.8	
Wass												
no.	495	0	53	6	81	149	0	0	1	0	38	823
%	60.2	-	6.1	0.7	9.8	18.1	-	-	0.1	-	4.6	
Whitefish												
no.	0	220	295	259	106	135	8	0	0	0	0	1023
%	-	21.5	28.8	25.3	10.4	13.2	0.8	-	-	-	-	
Willow												
no.	356	41	34	22	362	70	0	1	0	0	7	893
%	39.9	4.6	3.8	2.5	40.5	7.8	-	0.1	-	-	0.8	
Fairy Rock												
no.	175	46	51	15	294	63	0	0	0	0	0	644
%	27.2	7.1	7.9	2.3	45.7	9.8	-	-	-	-	-	

Table 8 . *Triaenophorus crassus* infestation levels in whitefish, 1977.

Lake	Gang no.	No. fish	Mean round weight(lb)	Mean no. cysts fish^{-1}	No. cysts per 100 lbs*	Lake classification
Pine II	1	19	7.06	0.58	24.68	A
Numakoos	1	19	1.63	1.89	70.34	B
James	1	25	2.16	5.96	369.79	C
Lake X	1	4	2.09	0.75	47.85	B
McPherson	1	25	3.19	1.72	71.89	B
MacBride	3	4	4.14	5.50	177.78	
	4	12	5.19	3.83	98.37	
	5	17	4.84	3.88	107.04	
	6	10	4.49	4.40	130.54	
	7	22	3.37	1.86	73.91	
	8	1	5.94	0	0	
	9	6	2.40	2.17	120.84	
	10	13	4.07	2.38	78.08	
	11	7	4.06	0.57	16.61	
		$\Sigma = 92$	$\bar{\bar{x}} = 4.19$	$\bar{\bar{x}} = 2.90$	$\bar{\bar{x}} = 92.35$	C
MacKerracher I	1	36	1.28	3.00	312.13	
	2	24	1.54	6.00	523.22	
	3	14	2.11	8.43	533.30	
		$\Sigma = 74$	$\bar{\bar{x}} = 1.52$	$\bar{\bar{x}} = 5.00$	$\bar{\bar{x}} = 438.60$	C
MacKerracher II	18	34	2.09	7.59	482.75	
	19	7	2.24	6.00	355.51	
	20	43	2.18	8.21	502.79	
		$\Sigma = 84$	$\bar{\bar{x}} = 2.15$	$\bar{\bar{x}} = 7.77$	$\bar{\bar{x}} = 482.16$	C

*adjusted to dressed weight

Table 9 . *Triaenophorus crassus* infestation levels in whitefish, 1978.

Lake	No. fish	Mean round weight (kg)	Mean no. cysts $fish^{-1}$	No. cysts per 100 lbs	Lake classification
Cuddle	11	0.623	0	0	A
Wass			no whitefish present		-
Max	24	1.050	2.04	88.15	C
Aswapiswanan	27	1.059	2.85	122.14	C
Ankle	25	0.650	6.40	446.54	C
Willow	29	1.224	1.83	67	B
Fairy Rock	27	0.823	3.15	173.49	C
Whitefish	37	1.140	0.24	9.7	A
Bearhead	26	1.723	0	0	A
Semple	27	1.782	0	0	A

Table 10. Regressions of mercury content (mg l^{-1}) on body size of pike and walleyes.

Lake	Species	Sample size	Linear equation*	Significance at P = 0.05
McPherson	pike	10	$\log_{10} Y = -.5228 + .0264 \log_{10} X$	non-sig.
			$\log_{10} Y = -.4784 - .0665 \log_{10} Z$	non-sig.
Pine II	pike	19	$\log_{10} Y = -4.8822 + 2.4466 \log_{10} X$	sig.
			$\log_{10} Y = -.7072 + .7465 \log_{10} Z$	sig.
James	pike	15	$\log_{10} Y = -6.1225 + 3.4133 \log_{10} X$	sig.
			$\log_{10} Y = -.2580 + .7534 \log_{10} Z$	non-sig.
Numakoos	pike	18	$\log_{10} Y = -4.4554 + 2.1309 \log_{10} X$	sig.
			$\log_{10} Y = -.8246 + .6462 \log_{10} Z$	sig.
Lake X	pike	8	$\log_{10} Y = -3.6560 + 1.7400 \log_{10} X$	sig.
			$\log_{10} Y = -.6362 + .5662 \log_{10} Z$	non-sig.
	walleye	14	$\log_{10} Y = -3.9347 + 2.1752 \log_{10} X$	sig.
			$\log_{10} Y = -.3272 + .7008 \log_{10} Z$	sig.
Ankle	pike	11	$\log_{10} Y = -4.5060 + 2.3623 \log_{10} X$	sig.
			$\log_{10} Y = -.4265 + .7801 \log_{10} Z$	sig.
	walleye	26	$\log_{10} Y = -3.2901 + 1.8858 \log_{10} X$	sig.
			$\log_{10} Y = -.1693 + .6857 \log_{10} Z$	sig.
Bearhead	pike	8	$\log_{10} Y = -.4620 - .0712 \log_{10} X$	non-sig.
			$\log_{10} Y = -.5287 + .4448 \log_{10} Z$	non-sig.
Fairy Rock	pike	21	$\log_{10} Y = -.9396 + .3177 \log_{10} X$	non-sig.
			$\log_{10} Y = -.5796 + .8797 \log_{10} Z$	sig.
	walleye	19	$\log_{10} Y = -2.9578 + 1.6351 \log_{10} X$	sig.
			$\log_{10} Y = -.2400 + .7378 \log_{10} Z$	sig.

Wass	pike	24	$\log_{10} Y = -2.7154 + 1.1144 \log_{10} X$	sig.
			$\log_{10} Y = -.7911 + .3876 \log_{10} Z$	sig.
Cuddle	pike	29	$\log_{10} Y = -5.0422 + 2.4761 \log_{10} X$	sig.
			$\log_{10} Y -.7192 + .6187 \log_{10} Z$	sig.
	walleye	26	$\log_{10} Y = -2.7452 + 1.2141 \log_{10} X$	sig.
			$\log_{10} Y = -.7509 + .3673 \log_{10} Z$	sig.
Semple	pike	13	$\log_{10} Y = -4.5327 + 2.2440 \log_{10} X$	sig.
			$\log_{10} Y = -.6386 + .7298 \log_{10} Z$	sig.
	walleye	8	$\log_{10} Y = -.6246 + .0342 \log_{10} X$	non-sig.
			$\log_{10} Y = -.5699 + .2211 \log_{10} Z$	non-sig.
Whitefish	pike	19	$\log_{10} Y = -4.4114 + 2.2065 \log_{10} X$	sig.
			$\log_{10} Y = -.5474 + .4398 \log_{10} Z$	non-sig.
Max	pike	22	$\log_{10} Y = -3.9167 + 1.7627 \log_{10} X$	sig.
			$\log_{10} Y = -.9429 + .7365 \log_{10} Z$	sig.
	walleye	26	$\log_{10} Y = -3.7728 + 1.9171 \log_{10} X$	sig.
			$\log_{10} Y = -.6264 + .5831 \log_{10} Z$	sig.
Willow	pike	20	$\log_{10} Y = -3.9528 + 1.8399 \log_{10} X$	sig.
			$\log_{10} Y = -.7599 + .5288 \log_{10} Z$	sig.
	walleye	24	$\log_{10} Y = -4.0512 + 2.1581 \log_{10} X$	sig.
			$\log_{10} Y = -.4876 + .6136 \log_{10} Z$	sig.

---

*For each species, X = length (cm) and Z = weight (kg).

Table 11. Age compositions and mean lengths and weights of walleyes, pike and whitefish from surveyed lakes.

Lake	Age (years)	Species								
		Walleye			Pike			Whitefish		
		No. fish	Mean length (mm)	Mean weight (gm)	No. fish	Mean length (mm)	Mean weight (gm)	No. fish	Mean length (mm)	Mean weight (gm)
Wass	1	1	170.00	50.00						
	2	3	205.67	86.67	2	258.50	160.00			
	3	14	250.79	167.50	2	436.50	540.00			
	4	9	298.99	282.22	3	452.67	576.67			
	5	11	317.55	392.27	11	528.22	964.55			
	6	23	383.04	616.96	11	514.55	900.91			
	7	73	391.99	663.36	5	541.80	1056.00			
	8	94	393.37	687.34	3	706.33	2586.67			
	9	58	399.10	722.93	1	620.00	1620.00			
	10	13	403.85	716.15	1	1020.00	6990.00			
	11	3	423.33	830.00	1	877.00	4800.00			
	12	1	391.00	660.00						
Semple	1							1	197.00	90.00
	2				2	299.50	75.00	1	310.00	460.00
	3				1	446.00	690.00			
	4	9	390.56	696.67	6	468.83	678.33	12	450.33	1441.67
	5	15	411.33	878.67	23	516.13	895.22	129	469.86	1685.74
	6	11	506.18	1403.64	13	574.00	1166.15	97	486.56	1981.34
	7	2	456.60	1520.00	3	654.00	1700.00	19	501.32	2193.68
	8	1	505.00	1340.00	1	648.00	1800.00	3	525.33	2666.67
	9				1	850.00	3940.00	1	490.00	2000.00
	10				1	829.00	3200.00			
	11	1	541.00	1050.00						
	14	1	422.00	840.00						

Fairy Rock	1							1	162.00	40.00
	2									
	3	4	246.00	147.50				4	279.00	292.50
	4	11	325.09	389.09	5	501.00	831.00	2	294.50	335.00
	5	34	391.65	697.94	4	570.50	1242.50	5	360.80	715.00
	6	45	425.44	856.22	9	605.44	1478.33	9	390.67	892.22
	7	30	445.57	986.00	7	619.43	1556.43	8	396.00	946.25
	8	22	438.91	1007.73	11	750.18	3098.64	11	421.64	1190.45
	9	13	431.00	868.85	8	706.00	2574.38	3	435.33	1190.00
	10	5	418.40	816.00	1	888.00	5130.00	1	448.00	1440.00
	11	5	440.00	901.00	3	844.00	4760.00			
	12				3	874.00	5113.33	1	432.00	1160.00
McBride	2				4	237.75	72.50			
	3				7	278.14	141.43			
	4				15	335.33	279.33			
	5				33	393.82	478.18			
	6				25	459.24	689.20			
	7				24	498.38	849.17			
	8				27	548.19	1152.96			
	9				31	595.06	1455.16			
	10				23	630.26	1763.04			
	11				33	671.21	2155.45			
	12				12	717.00	2827.50			
	13				16	778.31	3517.50			
	14				9	820.14	4242.22			
	15				8	890.00	6227.50			
	16				5	912.20	6300.00			
	17				5	937.60	6608.00			
	18				1	975.00	8050.00			
	19									
McPherson	2				1	269.00	160.00			
	3				1	349.00	340.00			
	4							1	388.00	850.00
	5				1	426.00	590.00	2	409.00	1140.00
	6							9	420.78	1213.33
	7				2	557.50	1080.00	33	441.91	1370.30
	8				2	669.50	1815.00	9	452.78	1527.78
	9				1	614.00	1660.00	2	482.50	1600.00
	10				1	672.00	2290.00			
	11							1	388.00	2130.00

"X"	4	2	325.00	360.00						
	5	6	382.17	576.67				1	308.00	380.00
	6	4	413.25	772.50	1	522.00	940.00	1	423.00	1150.00
	7	1	471.00	1150.00	2	569.50	1140.00	1	395.00	820.00
	8	1	537.00	1580.00						
	9				1	620.00	1450.00	1	458.00	1450.00
	10				3	709.00	2390.00			
	14				1	810.00	4050.00			
	15				1	948.00	4620.00			
James	2							1	187.00	100.00
	3									
	4							7	310.29	792.50
	5				3	473.00	706.67	4	378.75	792.50
	6				8	512.00	943.75	7	370.14	684.29
	7				3	536.33	983.33	8	407.75	1033.75
	8				1	590.00	1500.00	2	414.50	1045.00
Numakoos	3				1	348.00	350.00	2	270.50	250.00
	4				3	392.67	483.33	5	290.60	350.00
	5				4	439.50	637.50	3	371.00	683.33
	6				5	502.60	930.00	4	406.00	1175.00
	7				3	560.33	1200.00	4	411.25	962.50
	8				1	576.00	1550.00	1	437.00	1250.00
	12				1	700.00	3150.00			
	13				1	867.00	6550.00			
Pine	4				3	379.67	423.33	1	377.00	750.00
	5				7	427.29	592.86	2	381.50	925.00
	6				3	483.00	800.00	1	422.00	1150.00
	7				1	572.00	1300.00	5	435.20	1360.00
	8							2	438.00	1425.00
	9				1	677.00	2250.00	3	451.33	1666.67
	10							5	474.40	1850.00
	12				1	766.00	4000.00			
	15				1	868.00	5150.00			

Whitefish	3									
	4				2	535.00	1210.00			
	5				32	532.31	1157.19			
	6				103	599.96	1520.68	3	385.33	793.33
	7				67	636.24	1821.34	41	422.85	1128.05
	8				31	672.52	2213.71	86	432.87	1233.08
	9				14	708.57	2800.00	80	431.09	1251.98
	10				4	739.75	3775.00	9	450.00	1440.00
	11				1	865.00	5000.00			
Cuddle	1	2	202.50	85.00				1	482.00	1580.00
	2	1	188.00	65.00				6	156.50	57.50
	3	2	309.00	320.00				4	219.25	167.50
	4	31	405.39	766.13	2	260.00	157.50	4	207.50	152.50
	5	44	435.07	939.32	5	398.80	444.00	4	292.50	442.50
	6	8	451.13	1066.25	21	488.00	696.67	3	329.00	653.33
	7				37	513.14	777.03	1	396.00	1320.00
	8				27	573.37	1118.15			
	9				5	616.60	1374.00			
	11				1	573.00	1080.00			
	12							2	496.00	2450.00
	13				1	798.00	4050.00			
	14							1	470.00	2080.00
Aswapiswanan	2	2	181.00	51.00				1	467.00	1850.00
	3	5	223.20	109.40						
	4	2	237.50	132.00						
	5	6	315.00	299.33						
	6	6	377.83	605.83						
	7	17	407.24	754.06				11	404.82	966.36
	8	22	439.05	936.23				38	417.74	1106.89
	9	36	442.42	952.58				28	418.71	1118.64
	10	19	459.47	1085.16				7	424.57	1153.00
	11	4	498.50	1315.00				4	434.50	1299.25
	12	5	459.40	1059.40						

Max (commercial)	5	38	397.87	785.53	11	547.00	1232.73	6	384.83	808.33
	6	93	419.11	936.56	74	584.72	1477.30	15	402.33	913.33
	7	66	455.35	1214.39	56	627.30	1873.21	37	401.19	933.78
	8	33	479.42	1536.36	26	667.08	2348.08	80	427.23	1176.88
	9	11	500.55	1613.64	9	771.11	3416.67	54	435.98	1274.07
	10	4	557.75	2187.50	8	888.88	5293.75	25	451.72	1378.00
	11	1	525.00	2050.00	3	1027.00	6633.33	18	472.89	1613.89
	12	1	540.00	1800.00	7	1062.43	8228.57	6	461.00	1358.33
	13				3	1100.00	9066.67	4	486.50	1787.50
	14							1	548.00	2250.00
	15							1	480.00	1500.00
	17							1	551.00	2800.00
Enatik	1	4	195.75	75.00	1	308.00	200.00	1	134.00	50.00
	2	16	225.13	127.50	5	224.00	78.00	1	238.00	160.00
	3	28	276.04	228.21	9	317.22	332.22			
	4	24	344.29	447.50	5	347.20	288.00	10	318.30	500.00
	5	64	389.36	645.94	19	374.37	375.79	7	363.14	735.71
	6	76	419.09	813.55	34	421.24	520.29	18	394.28	1005.56
	7	24	468.16	1102.92	23	484.87	763.04	30	425.97	1210.67
	8	7	510.86	1491.43	27	520.70	941.11	59	444.39	1388.31
	9	1	498.00	1450.00	38	570.11	1198.16	33	448.82	1393.94
	10				24	611.58	1569.17	18	460.94	1520.00
	11				13	650.85	1733.85	15	464.00	1625.33
	12				4	706.00	2482.50	5	468.60	1678.00
	13				3	700.67	2550.00	2	468.00	1575.00
	14				2	793.00	3700.00			
Willow	1				3	265.67	113.33	1	189.00	75.00
	2				1	280.00	140.00	1	288.00	320.00
	3				1	420.00	390.00	2	334.50	550.00
	4	2	296.50	280.00	7	500.71	710.00			
	5	11	315.82	333.18	7	461.00	621.43	1	396.00	1085.00
	6	28	364.04	448.32	6	561.00	1185.00	3	445.00	1245.00
	7	117	367.44	530.98	5	703.20	3176.00	11	421.45	1199.55
	8	92	378.45	582.23				6	447.50	1357.50
	9	32	398.41	648.28	2	664.50	1885.00	7	443.57	1396.43
	10	7	409.14	716.43	2	788.50	4100.00	3	438.33	1231.67
	11	1	393.00	550.00				3	469.00	1586.67

Denison	2				1	231.00	220.00			
	3	5	253.50	212.00	3	342.67	286.67	2	288.50	290.00
	4	3	303.00	356.67	10	414.40	536.00	17	307.94	432.94
	5	22	320.64	381.36	24	456.08	642.50	20	399.45	558.50
	6	31	382.13	627.42	35	513.57	878.57	23	379.13	821.74
	7	69	419.78	814.64	32	554.84	1081.88	68	401.19	933.09
	8	40	442.40	904.75	19	595.95	1344.74	152	418.47	1031.84
	9	40	459.88	1049.75	5	659.60	1994.00	100	425.46	1090.20
	10	9	481.22	1354.44	3	709.67	2700.00	35	433.03	1142.86
	11	1	517.00	1520.00	3	798.67	3876.67	5	425.00	1070.00
	14				3	865.00	4930.00			
Mackerracher I	2	4	241.50	155.00	2	260.50	175.00	1	266,00	240.00
	3	4	293.50	290.00	4	341.00	315.00	2	246.00	190.00
	4	14	333.64	413.57	16	407.94	556.25	15	285.20	357.33
	5	20	380.15	597.00	46	441.26	660.87	58	315.17	488.45
	6	18	412.89	763.89	91	487.49	833.08	58	348.16	620.52
	7	12	466.25	1045.00	84	532.73	1037.02	27	399.96	874.44
	8	4	495.25	1282.50	35	567.29	1232.00	18	424.67	987.22
	9				15	609.60	1600.67	18	424.50	1053.33
	10				9	645.33	1891.11	7	427.86	1018.57
	11				3	636.67	2263.33	1	432.00	1320.00
	12				5	738.60	3366.00			
	13				1	802.00	4250.00			
	14				3	774.00	3690.00			
Mackerracher II	2				1	209.00	70.00			
	3	9	247.56	157.78	2	302.50	240.00			
	4	8	296.50	305.00	4	395.25	487.50	12	336.58	562.50
	5	3	359.67	340.00	6	451.67	660.00	14	356.93	705.71
	6	8	400.75	720.00	32	474.66	798.13	18	371.61	801.11
	7	9	445.78	982.22	42	535.52	1054.52	26	399.27	1000.00
	8	1	424.00	840.00	30	574.83	1286.67	21	413.29	1091.43
	9	1	490.00	1600.00	8	630.50	1753.75	14	430.71	1296.43
	10				11	661.36	2253.64	2	438.00	1395.00
	11				8	687.00	2562.50			
	13				1	721.00	2880.00			
	14				1	1029.00	6930.00			

Bearhead	2				6	262.67	157.50			
	3	7	317.71	361.43	14	336.71	297.14	2	343.50	700.00
	4	35	350.26	460.43	32	416.69	503.94	3	378.67	983.33
	5	43	382.21	612.44	38	493.13	827.76	2	416.00	1375.00
	6	18	404.00	754.44	19	564.05	1234.21	8	435.75	1625.00
	7	1	401.00	850.00	14	600.86	1548.57	11	455.09	1788.18
	8	1	488.00	1300.00	8	684.50	2256.25	9	466.00	1930.00
	9				2	595.00	2375.00	6	469.17	1983.33
	10	1	405.00	750.00	1	790.00	3850.00	1	520.00	2550.00
	12				3	946.33	6300.00			
Ankle	1	1	172.00	80.00						
	2				1	303.00	200.00			
	3	1	239.00	160.00						
	4	5	285.80	266.00	3	469.00	776.67	4	228.25	152.50
	5	1	303.00	310.00	3	549.33	1110.00			
	6				4	615.25	1760.00	1	283.00	270.00
	7	1	474.00	870.00	8	664.38	2176.25	6	354.83	606.67
	8	18	409.39	795.28	8	718.50	2823.75	8	347.25	561.25
	9	23	433.65	954.57	11	772.09	3635.45	16	387.50	815.63
	10	28	445.82	1018.75	8	803.63	4058.75	5	395.80	830.00
	11	10	478.20	1229.50	3	823.00	3923.33	5	392.20	842.00
	12	4	487.00	1307.50	1	931.00	7050.00	4	416.75	982.50
	13	3	468.33	1183.33	4	879.00	5170.00	1	388.00	880.00

Table 12. Age-specific mean length - mean weight relationships of walleyes, pike and whitefish.

Species	Lake	Length-weight equation $\log_e$ weight = a + b · $\log_e$ length	Correlation coefficient	Test F ratio and d.f.
walleye	Ankle	$Y = -9.764 + 2.726X$	0.993	640.55(1,9)
	Bearhead	$Y = -11.899 + 3.087X$	0.987	195.80(1,5)
	Mackerracher I	$Y = -10.818 + 2.896X$	1.000	5503.41(1,5)
	MackerracherII	$Y = -12.860 + 3.240X$	0.974	93.83(1,5)
	Denison	$Y = -9.978 + 2.766X$	0.997	1102.14(1,7)
	Willow	$Y = -10.173 + 2.779X$	0.987	223.10(1,6)
	Enatik	$Y = -11.859 + 3.074X$	1.000	7050.98(1,7)
	Max	$Y = -11.202 + 2.990X$	0.983	176.16(1,6)
	Aswapiswanan	$Y = -12.753 + 3.219X$	0.999	6590.10(1,9)
	Cuddle	$Y = -12.448 + 3.117X$	1.000	41725.72(1,4)
	X	$Y = -11.438 + 2.997X$	0.998	856.61(1,3)
	Fairy Rock	$Y = -12.364 + 3.160X$	0.998	1448.54(1,7)
	Semple	$Y = -9.148 + 2.641X$	0.884	17.92(1,5)
	Wass	$Y = -12.086 + 3.114X$	0.999	5228.75(1,10)
pike	Wass	$Y = -10.167 + 2.723X$	0.992	316.09(1,5)
	Semple	$Y = -11.571 + 2.939X$	0.997	1317.93(1,7)
	Fairy Rock	$Y = -13.859 + 3.306X$	0.999	3027.91(1,7)
	MacBride	$Y = -13.142 + 3.208X$	0.999	5598.72(1,15)
	X	$Y = -11.444 + 2.921X$	0.986	135.88(1,4)
	James	$Y = -13.844 + 3.311X$	0.986	68.88(1,2)
	Numakoos	$Y = -13.157 + 3.229X$	0.994	526.48(1,6)
	Pine	$Y = -12.426 + 3.101X$	0.997	767.69(1,5)
	Whitefish	$Y = -12.799 + 3.158X$	0.974	222.72(1,6)
	Cuddle	$Y = -10.461 + 2.763X$	0.987	220.63(1,6)
	Max	$Y = -10.447 + 2.791X$	0.997	1364.30(1,7)
	Enatik	$Y = -11.375 + 2.922X$	0.995	1094.61(1,12)
	Willow	$Y = -13.659 + 3.280X$	0.994	573.24(1,7)
	Denison	$Y = -8.880 + 2.537X$	0.975	170.25(1,9)
	Ankle	$Y = -12.496 + 3.107X$	0.998	2568.58(1,9)
	Bearhead	$Y = -11.458 + 2.950X$	0.991	455.95(1,8)

	Mackerracher I	Y = -11.049 + 2.886X	0.994	944.99(1,11)
	Mackerracher II	Y = -11.138 + 2.892X	0.998	2941.27(1,10)
whitefish	Semple	Y = -13.360 + 3.385X	0.999	4734.28(1,6)
	Fairy Rock	Y = -13.905 + 3.467X	0.999	3630.88(1,8)
	McPherson	Y = 1.413 + 0.958X	0.269	0.39(1,5)*
	X	Y = -13.559 + 3.400X	0.997	342.03(1,2)
	James	Y = -10.914 + 2,960X	0.998	890.84(1,4)
	Numakoos	Y = -13.034 + 3.320X	0.990	195.29(1,4)
	Pine	Y = -15.357 + 3.717X	0.982	134.95(1,5)
	Whitefish	Y = -12.133 + 3.168X	0.976	80.69(1,4)
	Cuddle	Y = -12.305 + 3.241X	0.999	4296.84(1,7)
	Aswapiswanan	Y = -17.596 + 4.076X	0.994	267.83(1,3)
	Max	Y = -12.037 + 3.149X	0.986	360.11(1,10)
	Enatik	Y = -10.493 + 2.904X	0.994	880.60(1,10)
	Willow	Y = -13.217 + 3.353X	0.997	1458.12(1,8)
	Denison	Y = -12.141 + 3.164X	0.993	485.39(1,7)
	Mackerracher I	Y = -11.485 + 3.053X	0.991	416.69(1,8)
	Mackerracher II	Y = -13.017 + 3.327X	0.998	1530.61(1,5)
	Bearhead	Y = -11.933 + 3.172X	0.996	826.66(1,6)
	Ankle	Y = -12.498 + 3.219X	0.997	1224.76(1,7)

* non-significant at P = 0.05

Walford plots for walleyes (Figs. 30-32), whitefish (Figs. 33-35) and pike (Figs. 36-38) showed significant relationships of successive mean lengths for all populations except those noted on Table 13. Estimates of L_∞ derived from Walford equations were unrealistically high for pike from Denison, Willow, Max, Enatik and MacBride Lakes and for walleyes from Mackerracher I Lake. In many cases, deletions of aberrent estimates of successive mean lengths from Walford regressions resulted in decreasing the slope from above unity to below unity (thus allowing an estimate of L_∞) and an increase in the correlation coefficient. Non-significant Walford regressions were usually associated with relatively small sample sizes and relatively few age groups of fish (Table 13). Realistic estimates of L_∞ for walleyes, whitefish and pike ranged from 413 mm to 722 mm, from 390 mm to 581 mm and from 596 to 957 mm, respectively.

To determine growth rates, age-specific mean lengths were transformed into straight lines according to the exponential and von Bertalanffy growth models. Regressions of $\log_e (L_\infty - l_t)$ on t (Table 14) were considered to represent the von Bertalanffy growth curve because these regressions provided estimates of parameters comprising the von Bertalanffy equation. Seven of the twelve walleye von Bertalanffy growth curves had correlation coefficients that were $\geqq$ correlation coefficients of their respective exponential counterparts. Eleven of the seventeen whitefish von Bertalanffy growth curves and ten of the seventeen pike von Bertalanffy growth curves had correlation coefficients that were $\geqq$ the correlation coefficients of their respective exponential counterparts (Tables 14, 15). Most of the pike and whitefish von Bertalanffy growth equations had urealistically

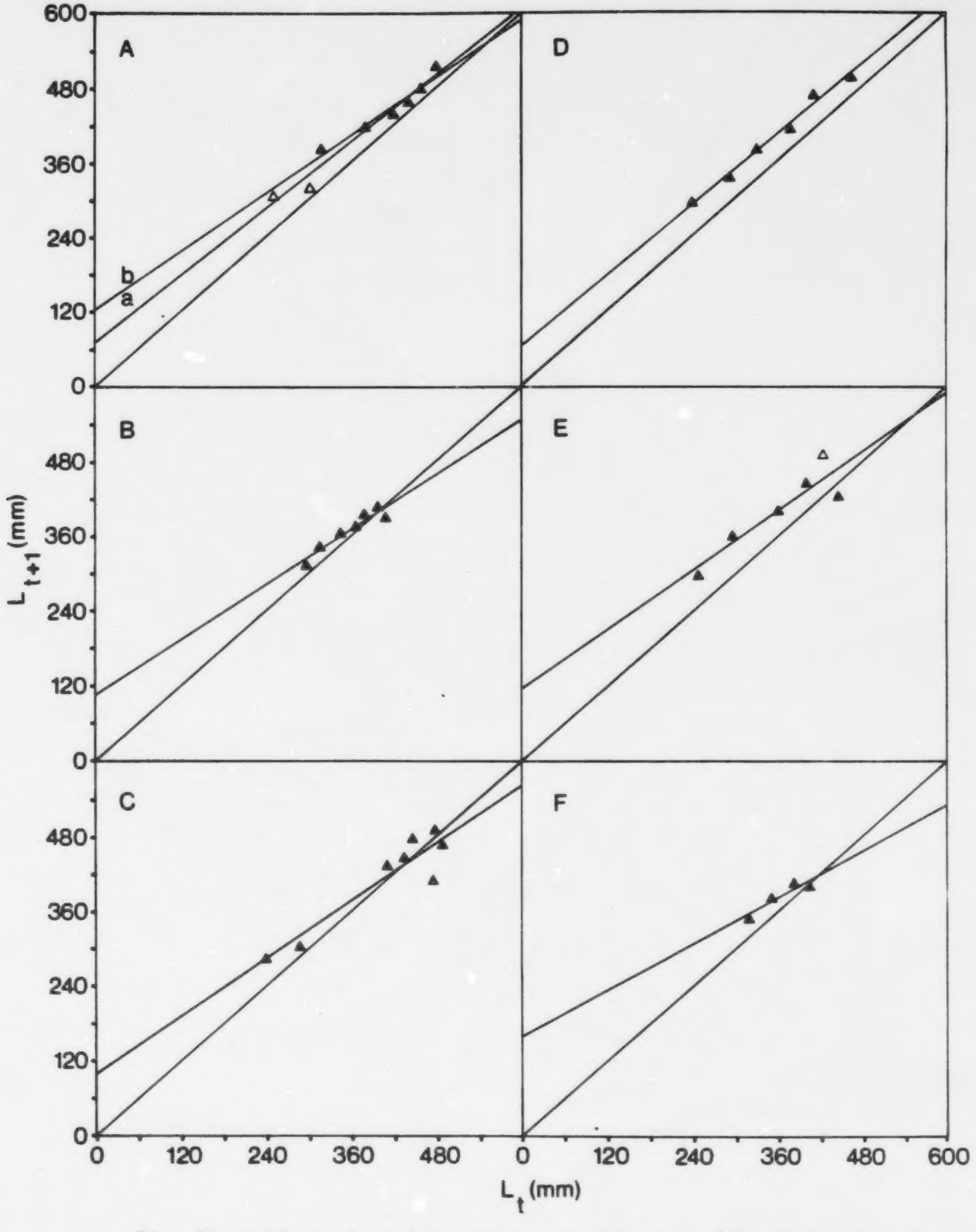

Fig. 30. Walford plots for walleyes from Denison (A), Willow (B), Ankle (C), Mackerracher I (D), Mackerracher II (E) and Bearhead (F) Lakes. Curve Aa includes all points. Curve Ab does not include open triangles.

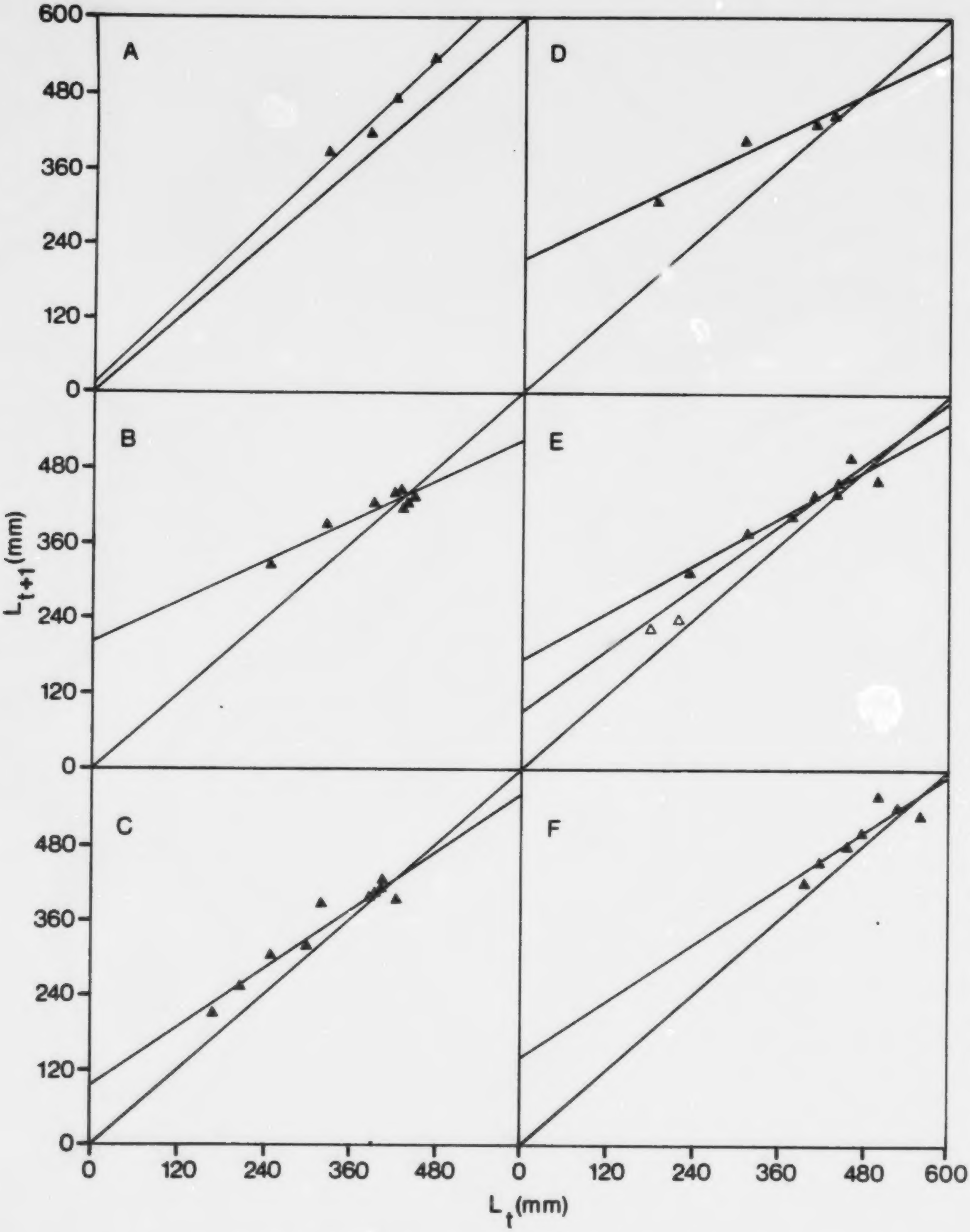

Fig. 31. Walford plots for walleyes from X(A), Fairy Rock (B), Wass (C), Cuddle (D), Aswapiswanan (E) and Max (F) Lakes.

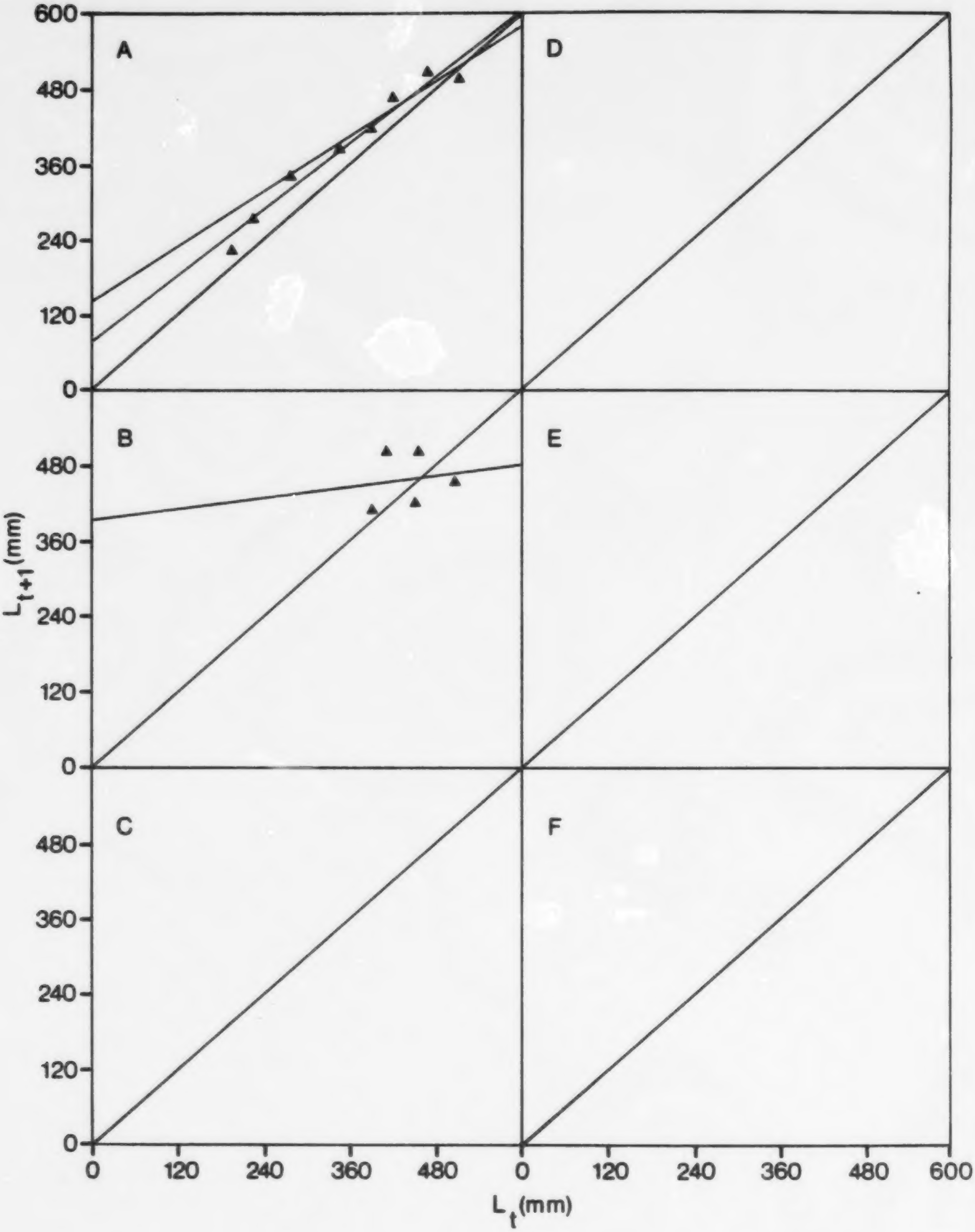

Fig. 32. Walford plots for walleyes from Enatik (A) and Semple (B) Lakes.

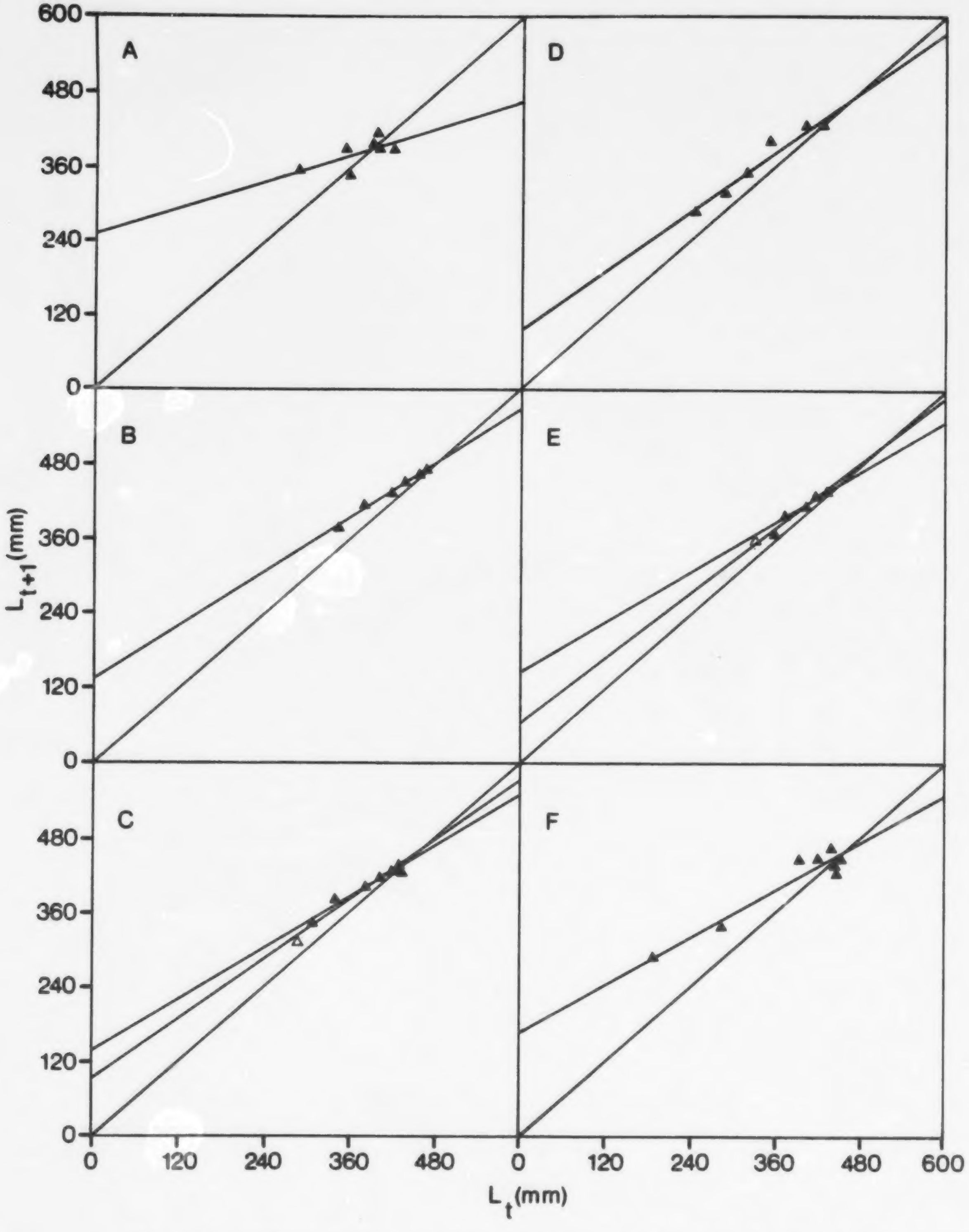

Fig. 33. Walford plots for whitefish from Ankle (A), Bearhead (B), Denison (C), Mackerracher I (D), Mackerracher II (E) and Willow(F) Lakes.

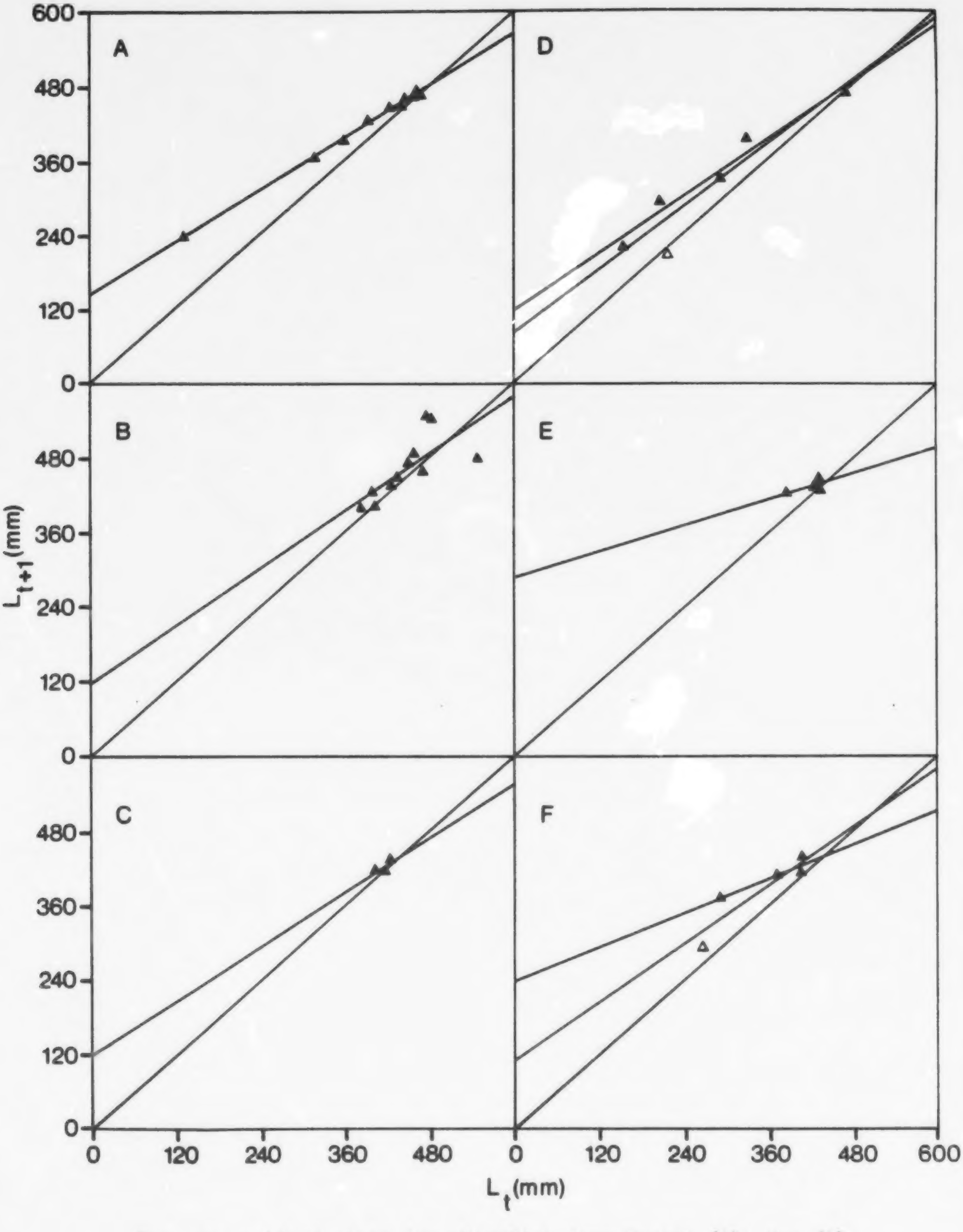

Fig. 34. Walford plots for whitefish from Enatik (A), Max (B), Aswapiswanan (C), Cuddle (D), Whitefish (E) and Numakoos (F) Lakes.

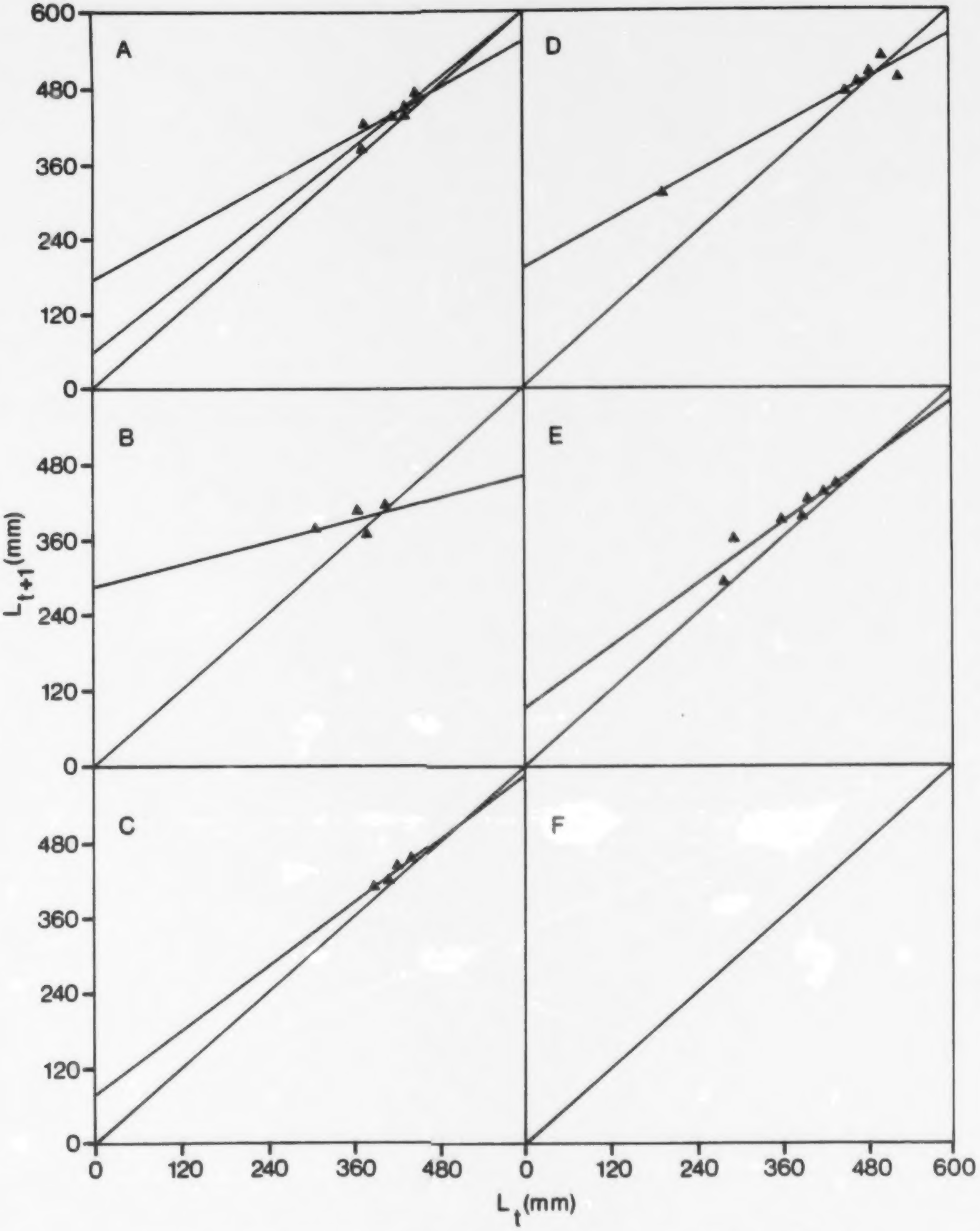

Fig. 35. Walford plots for whitefish from Pine (A), James (B), MacPherson (C), Semple (D) and Fairy Rock (E) Lakes.

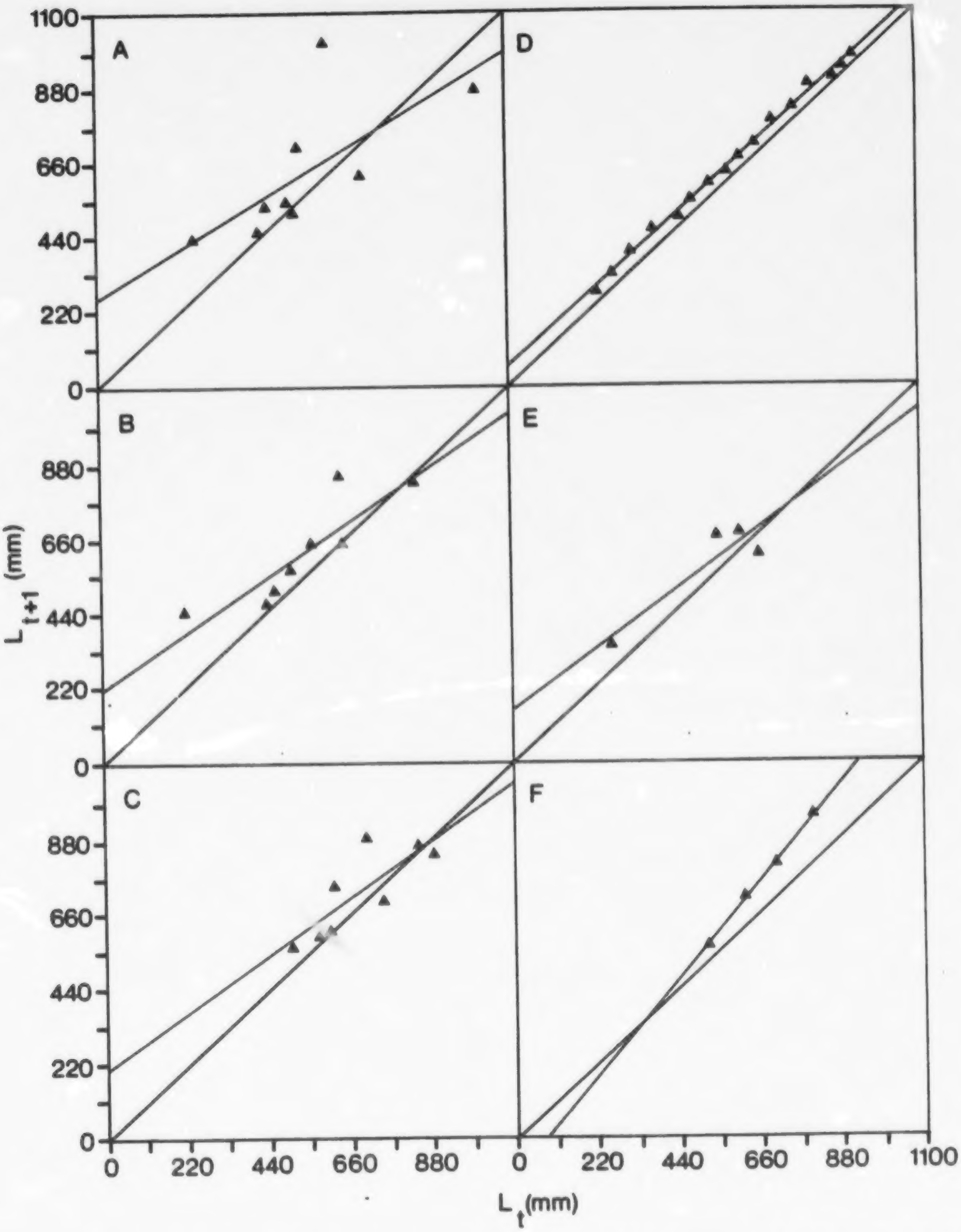

Fig. 36. Walford plots for pike from Wass (A), Semple (B), Fairy Rock (C), MacBride (D) , MacPherson (E) and X (F) Lakes.

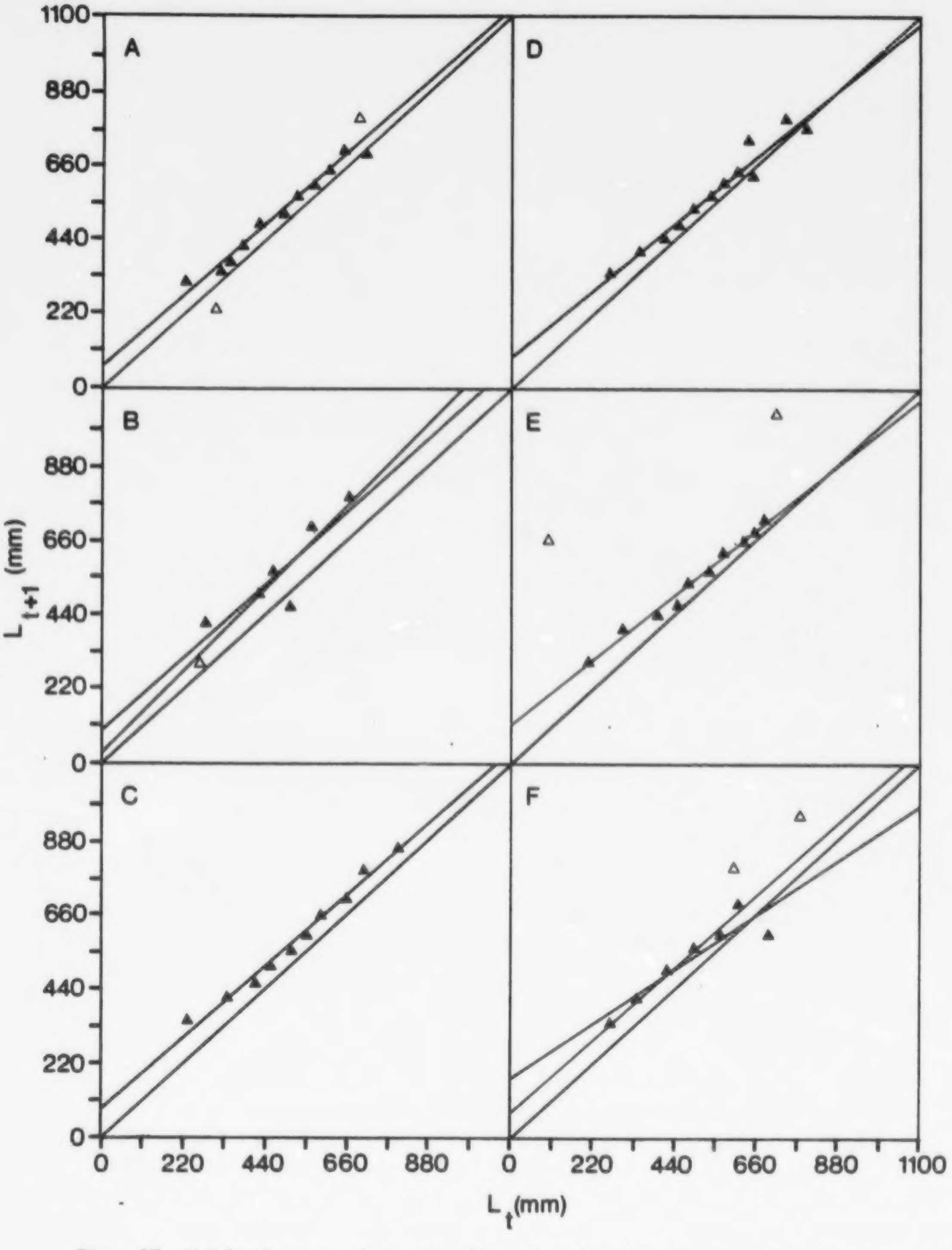

Fig. 37. Walford plots for pike from Enatik (A), Willow (B), Denison (C), Mackerracher I (D), Mackerracher II (E), and Bearhead (F) Lakes.

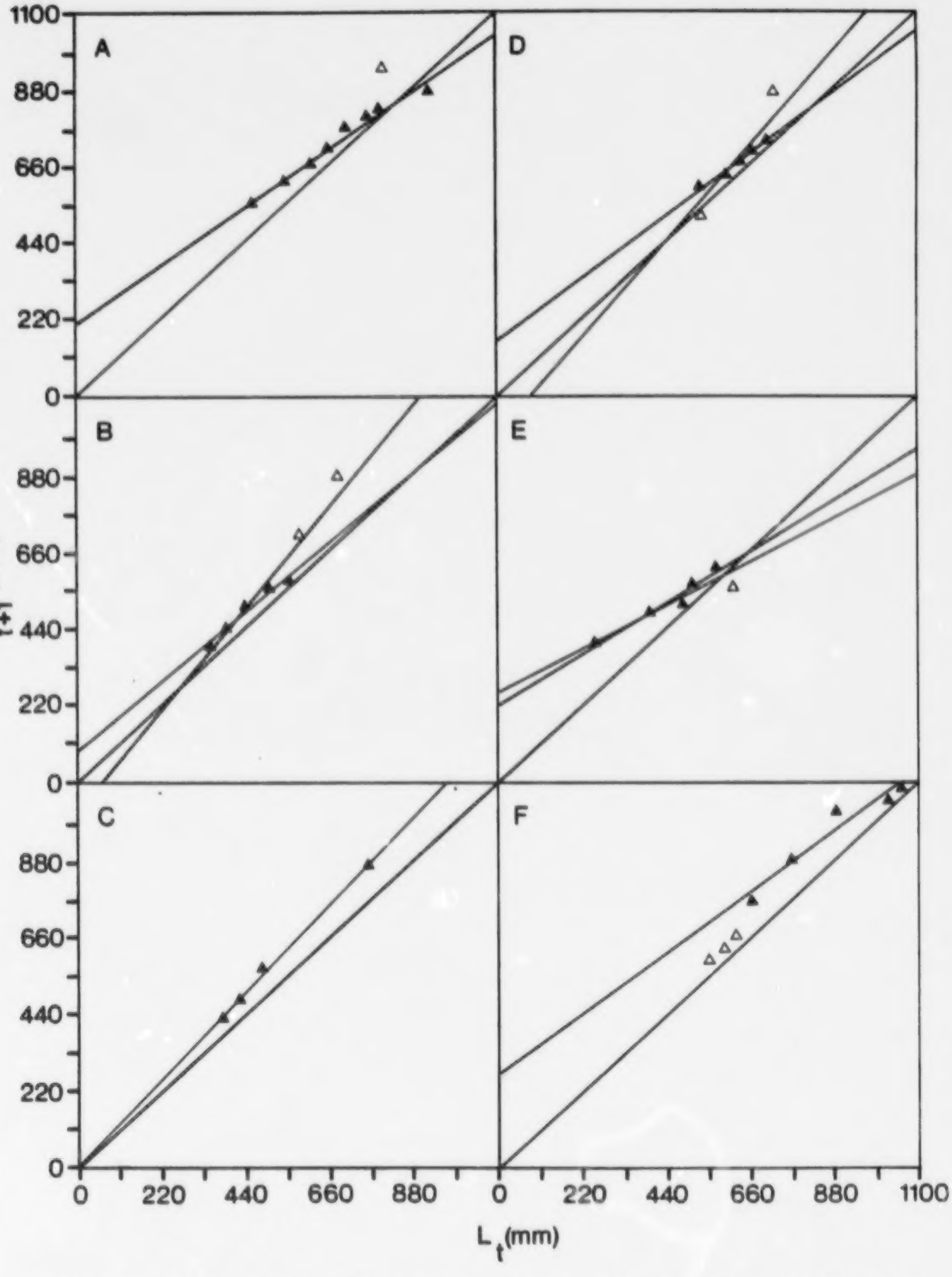

Fig. 38. Walford plots for pike from Ankle (A), Numakoos (B), Pine (C) Whitefish (D), Cuddle (E) and Max (F) Lakes.

Table 13. Linear equations of Walford plots fitted by regression.

Species	Lake	Walford plot $L_{t+1} = a + b \cdot L_t$	L_∞ (mm)	Age deleted	Correlation coefficient	Test F ratio and d.f.
walleye	Wass	Y = 92.118 + 0.782X	422.56	-	0.964	116.88(1,9)
	Semple	Y = 395.212 + 0.147X	-	-	-	0.07(1,3)*
	Fairy Rock	Y = 202.965 + 0.542X	443.16	-	0.950	55.11(1,6)
	X	Y = 15.003 + 1.096X	-	-	0.979	45.99(1,2)
	Cuddle	Y = 213.251 + 0.559X	483.56	1-2	0.979	45.17(1,2)
	Aswapiswanan	Y = 88.819 + 0.830X	522.46	-	0.962	100.51(1,8)
		Y = 171.891 + 0.637X	473.53	2-4	0.947	52.43(1,6)
	Max	Y = 136.472 + 0.756X	559.31	-	0.878	16.78(1,5)
	Enatik	Y = 75.725 + 0.893X	707.71	-	0.980	146.81(1,6)
		Y = 139.524 + 0.745X	547.15	1-3	0.966	56.07(1,4)
	Willow	Y = 105.711 + 0.744X	412.93	-	0.950	46.41(1,5)
	Denison	Y = 70.030 + 0.903X	721.96	-	0.983	167.79(1,6)
		Y = 121.826 + 0.787X	571.95	3-5	0.975	77.54(1,4)
	Mackerracher I	Y = 64.938 + 0.936X	1014.66	-	0.994	316.71(1,4)
	MackerracherII	Y = 112.419 + 0.801X	564.92	-	0.910	19.30(1,4)
		Y = 117.117 + 0.781X	534.78	6-7	0.905	13.59(1,3)
	Bearhead	Y = 159.938 + 0.617X	417.59	-	0.942	15.80(1,2)
	Ankle	Y = 97.012 + 0.779X	438.97	-	0.934	40.69(1,6)
whitefish	Semple	Y = 189.271 + 0.626X	506.07	-	0.977	84.53(1,4)
	Fairy Rock	Y = 92.323 + 0.815X	499.04	-	0.946	42.50(1,5)
	McPherson	Y = 75.609 + 0.857X	528.73	-	0.973	34.89(1,2)
	James	Y = 286.090 + 0.291X	403.51	-	0.550	0.87(1,2)*
		Y = 263.358 + 0.378X	423.41	5	0.977	21.18(1,1)*
	Numakoos	Y = 109.598 + 0.782X	488.98	-	0.901	13.01(1,3)
		Y = 237.520 + 0.457X	437.42	3-4	0.936	14.15(1,2)*

	Pine	Y = 57.518 + 0.901X	580.99	-	0.900	16.99(1,4)
		Y = 174.279 + 0.634X	476.17	4-5	0.855	8.18(1,3)*
	Whitefish	Y = 286.264 + 0.354X	443.13	-	0.690	1.82(1,2)*
	Aswapiswanan	Y = 118.422 + 0.733X	443.53	-	0.793	3.40(1,2)*
	Max	Y = 117.899 + 0.772X	517.10	-	0.718	9.60(1,9)
	Enatik	Y = 144.079 + 0.697X	475.51	-	0.999	2874.10(1,8)
	Willow	Y = 163.932 + 0.644X	460.48	-	0.953	59.91(1,6)
	Denison	Y = 91.487 + 0.801X	459.73	-	0.975	117.62(1,6)
		Y = 135.077 + 0.694X	441.43	3-4	0.977	102.99(1,5)
	Mackerracher I	Y = 88.715 + 0.807X	459.66	2-3	0.994	406.66(1,5)
	MackerracherII	Y = 59.822 + 0.888X	534.13	-	0.985	131.46(1,4)
		Y = 143.284 + 0.686X	456.32	4-6	0.982	54.88(1,2)
	Bearhead	Y = 131.996 + 0.733X	494.37	9-10	0.992	232.83(1,4)
	Ankle	Y = 238.032 + 0.389X	389.58	8-9	0.704	3.93(1,4)*
	Cuddle	Y = 83.037 + 0.844X	532.29	-	0.936	28.53(1,4)
		Y = 116.762 + 0.769X	505.46	2-3	0.978	66.87(1,3)
Pike	Wass	Y = 265.630 + 0.651X	761.12	9-10	0.915	30.68(1,6)
	Ankle	Y = 210.645 + 0.750X	842.58	11-12	0.988	250.44(1,6)
	Bearhead	Y = 70.924 + 1.010X	∞	-	0.907	32.32(1,7)
		Y = 176.760 + 0.731X	657.10	9-12	0.918	26.77(1,5)
	Mackerracher I	Y = 98.589 + 0.897X	957.17	-	0.977	209.87(1,10)
	MackerracherII	Y = 117.797 + 0.865X	872.57	11-14	0.994	700.99(1,8)
	Denison	Y = 82.099 + 0.965X	2345.69	-	0.991	456.79(1,8)
	Willow	Y = 35.557 + 1.099X	∞	-	0.920	27.69(1,5)
		Y = 101.541 + 0.979X	4835.29	1-2	0.882	13.94(1,4)
	Max	Y = 268.703 + 0.794X	1304.38	5-8	0.972	50.62(1,3)
	Enatik	Y = 67.131 + 0.957X	1561.19	1-2,10-11	0.984	270.72(1,9)
	Cuddle	Y = 256.850 + 0.569X	595.94	-	0.942	31.40(1,4)
		Y = 219.794 + 0.667X	660.04	8-9	0.975	57.13(1,3)
	Whitefish	Y = 110.215 + 1.249X	∞	-	0.946	42.98(1,5)
		Y = 159.959 + 0.812X	850.85	3-4,9-10	0.991	164.98(1,3)
	Semple	Y = 220.736 + 0.734X	829.83	-	0.872	19.10(1,6)
	Fairy Rock	Y = 205.845 + 0.768X	887.26	-	0.820	12.34(1,6)
	McBride	Y = 67.605 + 0.967X	2048.64	-	0.998	2714.92(1,12)

McPherson	Y = 160.266 + 0.788X	755.97	-	0.914	10.17(1,2)*
X	Y = -104.707 + 1.299X	∞	-	0.999	1239.23(1,2)
James	Y = 530.652 + 0.045X	555.66	-	0.323	0.12(1,1)*
Numakoos	Y = -79.964 + 1.307X	∞	-	0.973	90.18(1,5)
	Y = 89.688 + 0.902X	915.18	8–13	0.978	65.25(1,3)
Pine	Y = 6.667 + 1.130X	∞	-	0.998	448.44(1,2)

* non-significant at P = 0.05

Table 14. Relationships of $\log_e (L_\infty - l_t)$ and t for walleyes, pike and whitefish from surveyed lakes.

Species	Lake	$\log_e (L_\infty - l_t) = a - b \cdot t$	Ages deleted	Correlation coefficient	Test F ratio and d.f.
walleye	Ankle	$\log_e (438.97 - l_t) = 6.166 - 0.315t$	9	0.954	30.49(1,3)
	Bearhead	$\log_e (417.59 - l_t) = 5.970 - 0.457t$	6	0.995	181.93(1,2)
	Mackerracher I	$\log_e (1014.66 - l_t) = 6.785 - 0.067t$	-	0.998	1579.91(1,5)
	Mackerracher II	$\log_e (534.78 - l_t) = 6.704 - 0.316t$	8	0.995	396.11(1,4)
	Denison	$\log_e (571.95 - l_t) = 6.461 - 0.205t$	-	0.985	222.45(1,7)
	Willow	$\log_e (412.93 - l_t) = 5.959 - 0.303t$	10	0.934	34.36(1,5)
	Enatik	$\log_e (547.15 - l_t) = 6.283 - 0.258t$	8	0.989	262.46(1,6)
	Max	$\log_e (559.31 - l_t) = 6.695 - 0.297t$	10	0.991	270.21(1,5)
	Aswapiswanan	$\log_e (522.46 - l_t) = 6.255 - 0.200t$	11	0.971	134.08(1,8)
	Cuddle	$\log_e (483.56 - l_t) = 6.404 - 0.486t$	-	0.976	78.97(1,4)
	Fairy Rock	$\log_e (443.16 - l_t) = 7.805 - 0.796t$	9-11	0.996	362.07(1,3)
	Wass	$\log_e (422.56 - l_t) = 5.976 - 0.321t$	-	0.977	171.24(1,8)
pike	Ankle	$\log_e (842.58 - l_t) = 7.401 - 0.361t$	-	0.967	101.35(1,7)
	Bearhead	$\log_e (657.10 - l_t) = 6.927 - 0.395t$	-	0.985	129.47(1,4)
	Mackerracher I	$\log_e (957.17 - l_t) = 6.774 - 0.107t$	11,13,14	0.991	434.11(1,8)
	Mackerracher II	$\log_e (872.57 - l_t) = 6.752 - 0.136t$	-	0.997	1661.69(1,9)
	Denison	$\log_e (2345.69 - l_t) = 7.696 - 0.030t$	-	0.993	618.10(1,9)
	Willow	$\log_e (4835.29 - l_t) = 8.439 - 0.013t$	-	0.961	85.38(1,7)
	Enatik	$\log_e (1561.19 - l_t) = 7.251 - 0.040t$	-	0.984	356.51(1,12)
	Max	$\log_e (1304.38 - l_t) = 7.711 - 0.179t$	-	0.965	95.67(1,7)

	Cuddle	$\log_e (660.04 - l_t) = 7.277 - 0.416t$	9	0.985	133.81(1,4)
	Whitefish	$\log_e (850.85 - l_t) = 6.414 - 0.182t$	-	0.985	167.65(1,5)
	Numakoos	$\log_e (915.18 - l_t) = 6.684 - 0.110t$	13	0.997	887.22(1,5)
	James	$\log_e (555.66 - l_t) = 8.077 - 0.727t$	-	0.998	203.40(1,1)
	McPherson	$\log_e (755.97 - l_t) = 6.680 - 0.206t$	8	0.981	101.34(1,4)
	MacBride	$\log_e (2048.64 - l_t) = 7.574 - 0.033t$	-	0.997	2920.16(1,15)
	Fairy Rock	$\log_e (887.26 - l_t) = 6.513 - 0.143t$	8	0.986	102.65(1,3)
	Semple	$\log_e (829.83 - l_t) = 6.639 - 0.182t$	7	0.977	84.47(1,4)
	Wass	$\log_e (761.12 - l_t) = 6.379 - 0.156t$	8	0.957	54.03(1,5)
whitefish	Ankle	$\log_e (389.58 - l_t) = 9.227 - 0.880t$	8	0.934	13.68(1,2)*
	Bearhead	$\log_e (494.37 - l_t) = 5.964 - 0.317t$	-	0.995	481.44(1,5)
	Mackerracher I	$\log_e (459.66 - l_t) = 6.184 - 0.290t$	9-11	0.931	32.31(1,5)
	Mackerracher II	$\log_e (456.32 - l_t) = 6.224 - 0.322t$	-	0.987	183.65(1,5)
	Denison	$\log_e (441.43 - l_t) = 6.574 - 0.427t$	11	0.989	279.81(1,6)
	Willow	$\log_e (460.48 - l_t) = 5.869 - 0.332t$	6,8,9	0.997	756.29(1,4)
	Enatik	$\log_e (475.51 - l_t) = 6.345 - 0.355t$	-	0.994	789.00(1,9)
	Max	$\log_e (517.10 - l_t) = 5.947 - 0.187t$	12	0.976	122.33(1,6)
	Cuddle	$\log_e (505.46 - l_t) = 6.874 - 0.400t$	1,13,14	0.978	87.56(1,4)
	Whitefish	$\log_e (443.13 - l_t) = 8.318 - 0.864t$	8	0.993	66.94(1,1)
	Numakoos	$\log_e (437.42 - l_t) = 6.827 - 0.525t$	8	0.973	54.26(1,3)
	James	$\log_e (423.41 - l_t) = 6.726 - 0.545t$	-	0.970	64.46(1,4)
	McPherson	$\log_e (528.73 - l_t) = 5.835 - 0.204t$	11	0.963	50.55(1,4)
	Fairy Rock	$\log_e (499.04 - l_t) = 6.044 - 0.211t$	12	0.995	670.66(1,7)
	Semple	$\log_e (506.07 - l_t) = 6.326 - 0.558t$	7	0.999	1135.23(1,3)

Pine	$\log_e (476.17 - 1_t) = 5.795 - 0.284t$	10	0.977	82.65(1,4)
Aswapiswanan	$\log_e (443.53 - 1_t) = 5.627 - 0.322t$	-	0.942	23.80(1,3)

---

* non-significant at $P = 0.05$

Table 15. Exponential and von Bertalanffy growth curves of walleyes, pike and whitefish.

Species	Lake	Growth curves			
		Exponential			von Bertalanffy
		$\log_e l_t = a + b \cdot \log_e t$	Age range	Correlation coefficient	$l_t = L_\infty (1 - e^{-k (t - t_o)})$
walleye	Ankle	log Y = 5.080 + 0.452 log X	1-12	.970	$l_t = 438.97 (1 - e^{-.315(t - .26)})$
	Bearhead	log Y = 5.335 + 0.377 log X	3- 8	.947	$l_t = 417.59 (1 - e^{-.457(t + .14)})$
	Mackerracher I	log Y = 5.110 + 0.521 log X	2- 8	.998	$l_t = 1014.66 (1 - e^{-.067(t + 2.05)})$
	Mackerracher II	log Y = 4.873 + 0.604 log X	3- 9	.981	$l_t = 534.78 (1 - e^{-.316(t - 1.34)})$
	Denison	log Y = 4.942 + 0.546 log X	3-11	.994	$l_t = 571.95 (1 - e^{-.205(t - .55)})$
	Willow	log Y = 5.188 + 0.362 log X	4-10	.996	$l_t = 412.93 (1 - e^{-.303(t + .20)})$
	Enatik	log Y = 5.174 + 0.486 log X	1- 8	.982	$l_t = 547.15 (1 - e^{-.258(t + .08)})$
	Max	log Y = 5.218 + 0.465 log X	5-10	.983	$l_t = 559.31 (1 - e^{-.297(t - 1.24)})$
	Aswapiswanan	log Y = 4.730 + 0.628 log X	2-11	.985	$l_t = 522.46 (1 - e^{-.200(t + .02)})$
	Cuddle	log Y = 4.767 + 0.800 log X	1- 6	.963	$l_t = 483.56 (1 - e^{-.486(t - .46)})$
	Fairy Rock	log Y = 4.768 + 0.711 log X	3- 7	.981	$l_t = 443.16 (1 - e^{-.796(t - 2.15)})$
	Wass	log Y = 5.080 + 0.443 log X	1-10	.983	$l_t = 422.56 (1 - e^{-.321(t + .22)})$
	X	log Y = 4.809 + 0.698 log X	4- 8	.992	
pike	Ankle	log Y = 5.340 + 0.587 log X	2-13	.995	$l_t = 842.58 (1 - e^{-.361(t - 1.84)})$
	Bearhead	log Y = 5.095 + 0.674 log X	2-12	.983	$l_t = 657.10 (1 - e^{-.395(t - 1.11)})$
	Mackerracher I	log Y = 5.204 + 0.553 log X	2-14	.995	$l_t = 957.17 (1 - e^{-.107(t + .84)})$
	Mackerracher II	log Y = 4.933 + 0.693 log X	2-14	.982	$l_t = 872.57 (1 - e^{-.136(t + .14)})$

	Denison	$\log Y = 5.059 + 0.657 \log X$	2-14	.995	$l_t = 2345.69 (1 - e^{-.030(t + 2.14)})$
	Willow	$\log Y = 5.469 + 0.494 \log X$	1-10	.962	$l_t = 4835.29 (1 - e^{-.013(t + 3.44)})$
	Enatik	$\log Y = 4.991 + 0.618 \log X$	1-14	.994	$l_t = 1561.19 (1 - e^{-.040(t + 2.56)})$
	Max	$\log Y = 4.906 + 0.816 \log X$	5-13	.975	$l_t = 1304.38 (1 - e^{-.179(t - 3.00)})$
	Cuddle	$\log Y = 4.930 + 0.709 \log X$	3-12	.958	$l_t = 660.04 (1 - e^{-.416(t - 1.89)})$
	Whitefish	$\log Y = 5.799 + 0.379 \log X$	3-10	.953	$l_t = 850.85 (1 - e^{-.182(t - 1.83)})$
	Numakoos	$\log Y = 5.176 + 0.583 \log X$	3-13	.986	$l_t = 915.18 (1 - e^{-.110(t + 1.23)})$
	James	$\log Y = 5.430 + 0.450 \log X$	5- 8	.987	$l_t = 555.66 (1 - e^{-.727(t - 2.42)})$
	McPherson	$\log Y = 5.194 + 0.579 \log X$	2-10	.987	$l_t = 755.97 (1 - e^{-.206(t - .25)})$
	MacBride	$\log Y = 4.921 + 0.672 \log X$	2-19	.997	$l_t = 2048.64 (1- e^{-.033(t + 1.54)})$
	Fairy Rock	$\log Y = 5.468 + 0.531 \log X$	4-12	.963	$l_t = 887.26 (1 - e^{-.143(t + 1.92)})$
	Semple	$\log Y = 5.110 + 0.710 \log X$	2-10	.961	$l_t = 829.83 (1 - e^{-.182(t + .45)})$
	Wass	$\log Y = 5.187 + 0.650 \log X$	2-11	.934	$l_t = 761.12 (1 - e^{-.156(t + 1.64)})$
	X	$\log Y = 5.161 + 0.602 \log X$	6-15	.979	—
	Pine	$\log Y = 5.048 + 0.646 \log X$	4-15	.994	—
whitefish	Ankle	$\log Y = 4.810 + 0.491 \log X$	4-13	.940	$l_t = 389.58 (1 - e^{-.880(t - 3.71)})$
	Bearhead	$\log Y = 5.507 + 0.312 \log X$	3-10	.986	$l_t = 494.37 (1 - e^{-.317(t + .75)})$
	MacKerracher I	$\log Y = 5.204 + 0.373 \log X$	2-11	.947	$l_t = 459.66 (1 - e^{-.290(t - .18)})$
	Mackerracher II	$\log Y = 5.395 + 0.301 \log X$	4-10	.996	$l_t = 456.32 (1 - e^{-.322(t - .30)})$
	Denison	$\log Y = 5.292 + 0.341 \log X$	3-11	.976	$l_t = 441.43 (1 - e^{-.427(t - 1.13)})$
	Willow	$\log Y = 5.359 + 0.352 \log X$	1-11	.966	$l_t = 460.48 (1 - e^{-.332(t + .29)})$
	Enatik	$\log Y = 5.058 + 0.473 \log X$	1-13	.974	$l_t = 475.51 (1 - e^{-.355(t - .51)}$
	Max	$\log Y = 5.473 + 0.283 \log X$	5-17	.938	$l_t = 517.10 (1 - e^{-.187(t + 1.61)})$
	Cuddle	$\log Y = 5.037 + 0.452 \log X$	1-14	.972	$l_t = 505.46 (1 - e^{-.400(t - 1.62)})$

Whitefish	$\log Y = 5.57 + 0.250 \log X$	5-11	.961	$l_t = 443.13 (1 - e^{-.864(t - 2.57)})$
Numakoos	$\log Y = 5.009 + 0.528 \log X$	3- 8	.970	$l_t = 437.42 (1 - e^{-.525(t - 1.42)})$
James	$\log Y = 4.880 + 0.587 \log X$	2- 8	.974	$l_t = 423.41 (1 - e^{-.545(t - 1.24)})$
McPherson	$\log Y = 5.603 + 0.253 \log X$	4- 9	.985	$l_t = 528.73 (1 - e^{-.204(t + 2.13)})$
Fairy Rock	$\log Y = 5.138 + 0.423 \log X$	1-12	.983	$l_t = 499.04 (1 - e^{-.211(t + .80)})$
Semple	$\log Y = 5.386 + 0.432 \log X$	1- 9	.965	$l_t = 506.07 (1 - e^{-.558(t - .18)})$
Pine	$\log Y = 5.572 + 0.252 \log X$	4-10	.972	$l_t = 476.17 (1 - e^{-.284(t + 1.30)})$
Aswapiswanan	$\log Y = 5.785 + 0.124 \log X$	6-10	.967	$l_t = 443.53 (1 - e^{-.322(t + 1.45)})$
X	$\log Y = 4.870 + 0.583 \log X$	5- 9	.847	

large t_o correction values whereas relatively few of the walleye von Bertalanffy equations had t_o values that were greater than one year (Table 15, Figs. 39-49). Instantaneous growth rates of walleyes ranged from 0.362 in Willow Lake to 0.809 in Cuddle Lake. Instantaneous growth rates of pike ranged from 0.379 in Whitefish Lake to 0.816 in Max Lake. Instantaneous growth rates of whitefish ranged from 0.124 in Aswapiswanan Lake to 0.587 in James Lake (Table 15, Figs. 50-57).

Stepwise analyses of covariance (ANCOVA) were performed to determine whether or not significant differences existed among the slopes of regressions of $\log_e (L_\infty - l_t)$ on t, i.e. the Brody growth coefficients, of pike (Table 16), walleyes (Table 17) and whitefish (Table 18). Differences among growth curve elevations were not considered in creating the groups shown on Tables 16-18. The groups were formed so that the first Brody growth coefficient of each group was significantly different from the first coefficient of the following group but was not significantly different from the lowest coefficient of its own group. Thus overlapping of groups was not tested. Pike displayed the greatest among lake differences in Brody growth coefficients while whitefish growth varied the least among lakes (Tables 16, 18).

Age-specific maturity frequencies (Table 19) were transformed as described by Lysack (1981) to derive instantaneous maturity rates and estimate ages at which 50% of the populations were mature (Table 20). Populations not listed on Tables 19 and 20 had extremely aberrent age-specific maturity frequencies. Eight of the 19 populations considered had non-significant regressions of maturity frequencies and age (Table 20).

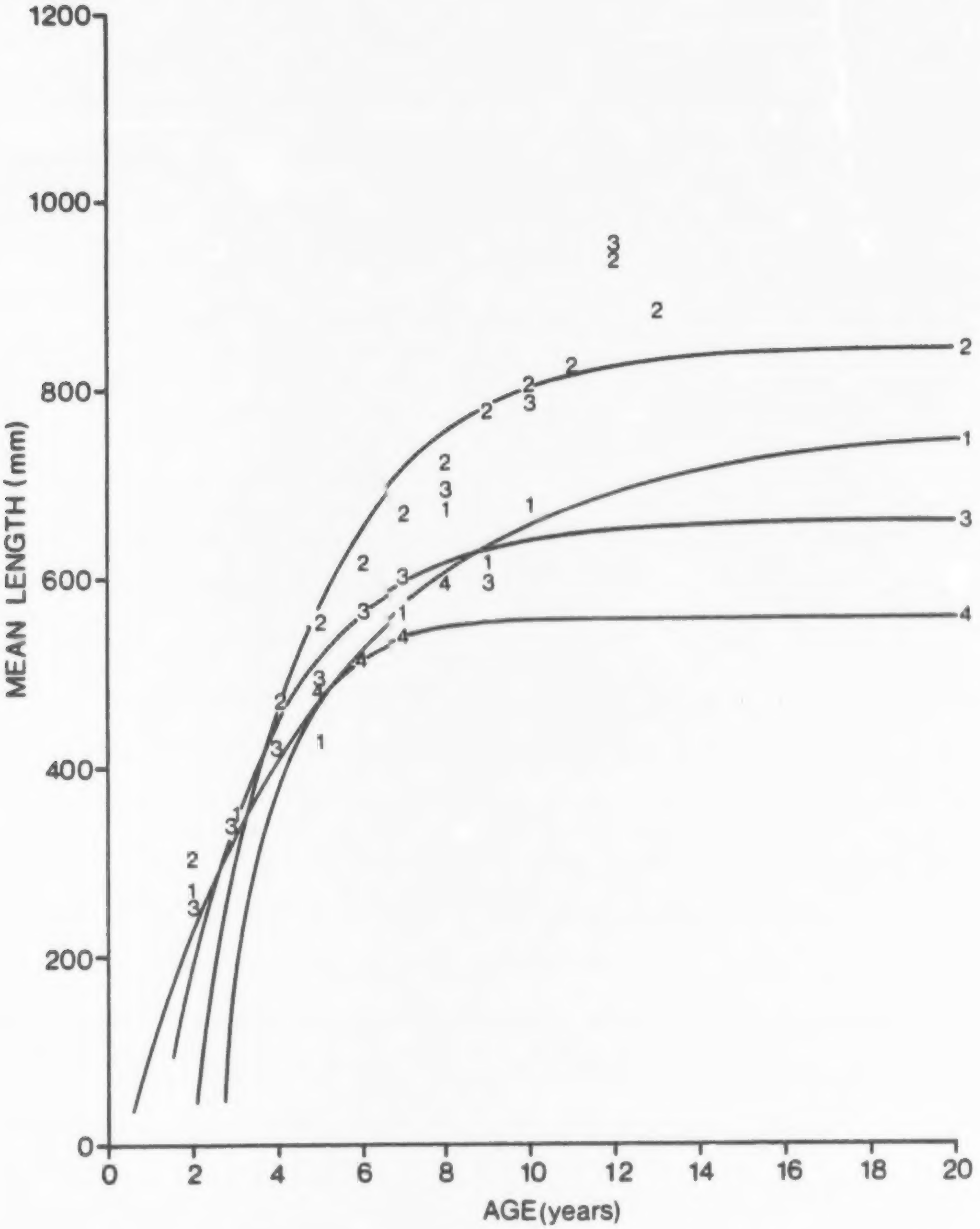

Fig. 39. Von Bertalanffy growth curves of pike from MacPherson (1), Ankle (2), Bearhead (3) and James (4) Lakes.

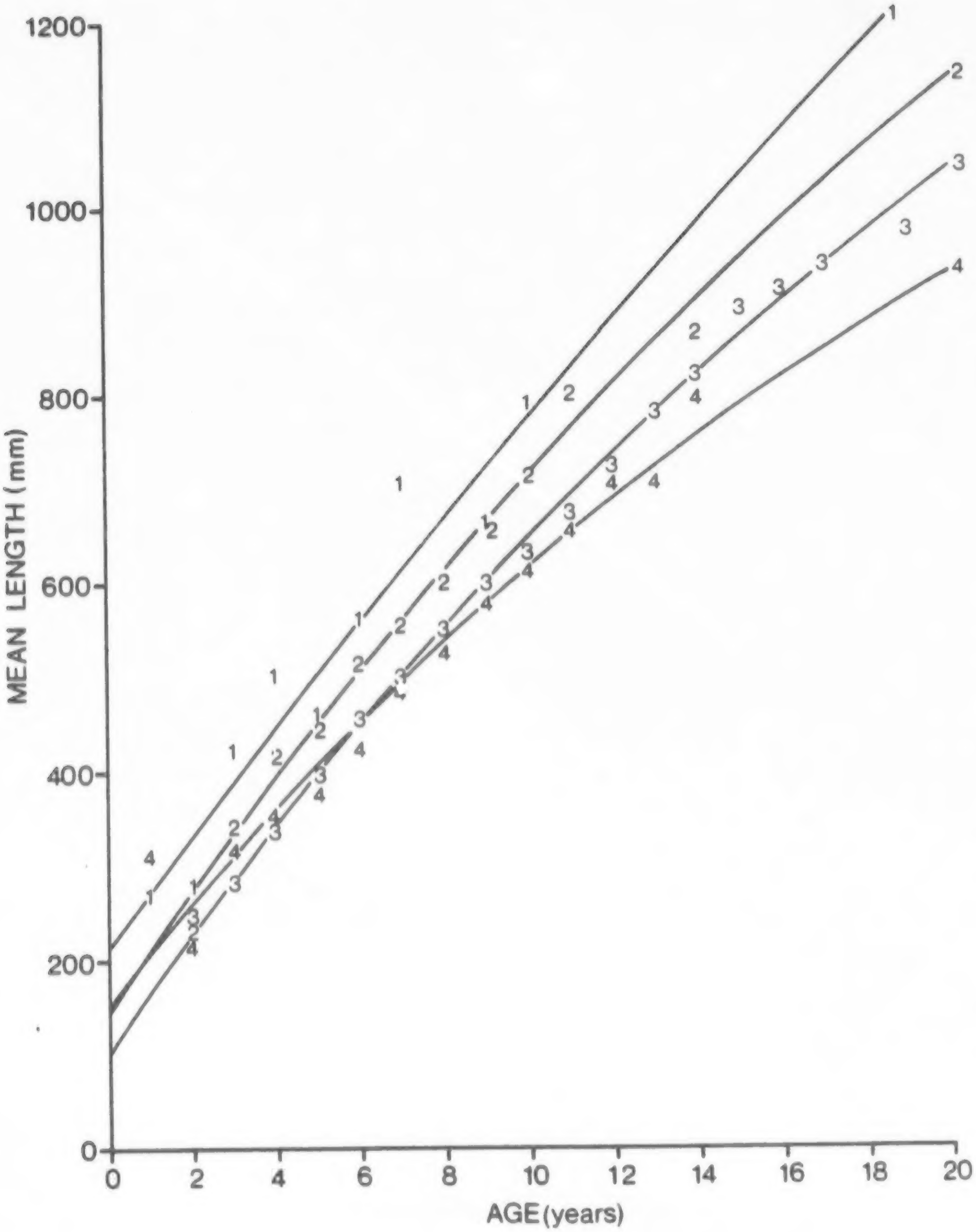

Fig. 40. Von Bertalanffy growth curves of pike from Willow (1), Denison (2), MacBride (3) and Enatik (4) Lakes.

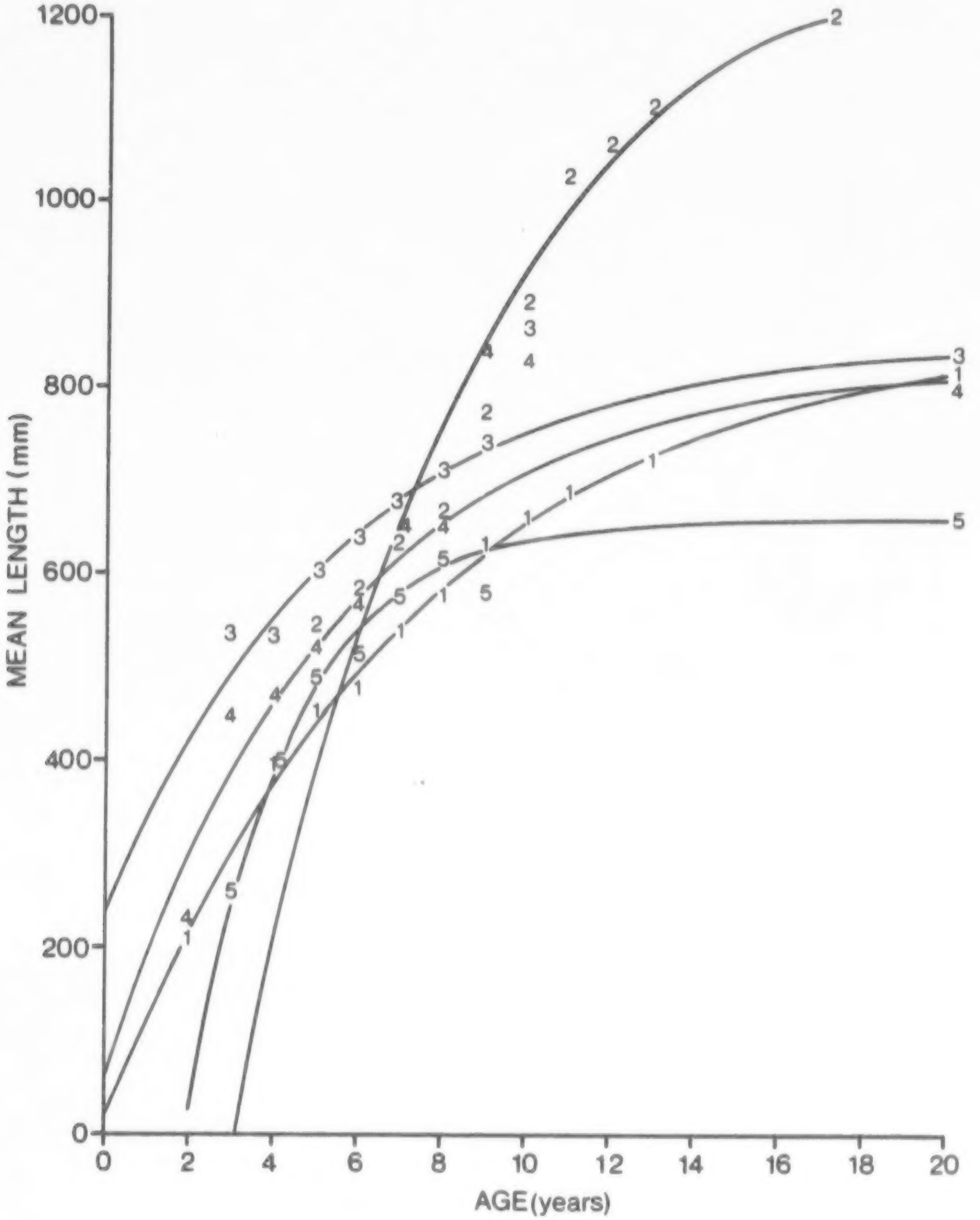

Fig. 41. Von Bertalanffy growth curves of pike from Mackerracher II (1), Max (2), Whitefish (3), Semple (4) and Cuddle (5) Lakes.

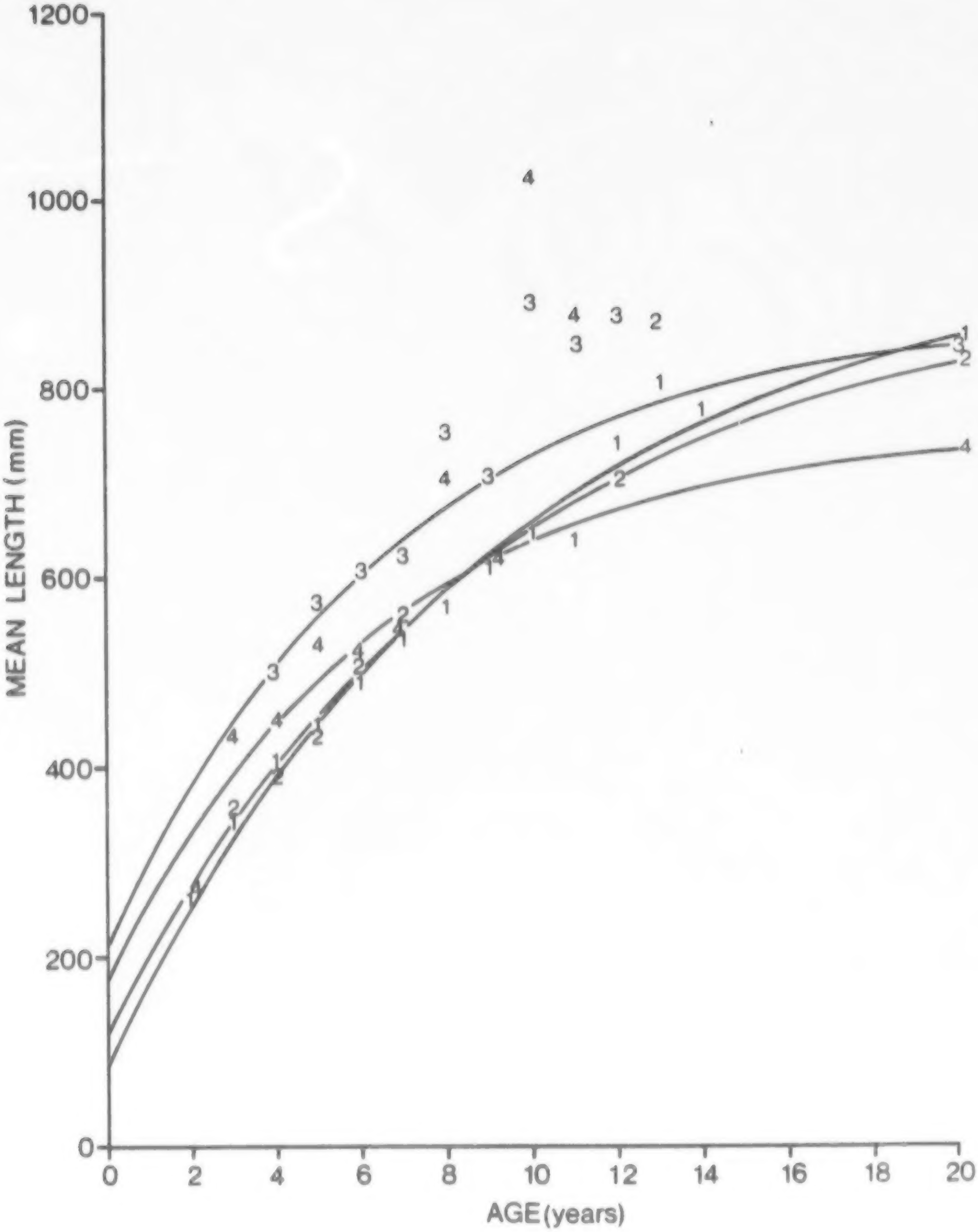

Fig. 42. Von Bertalanffy growth curves of pike from Mackerracher I (1), Numakoos (2), Fairy Rock (3) and Wass (4) Lakes.

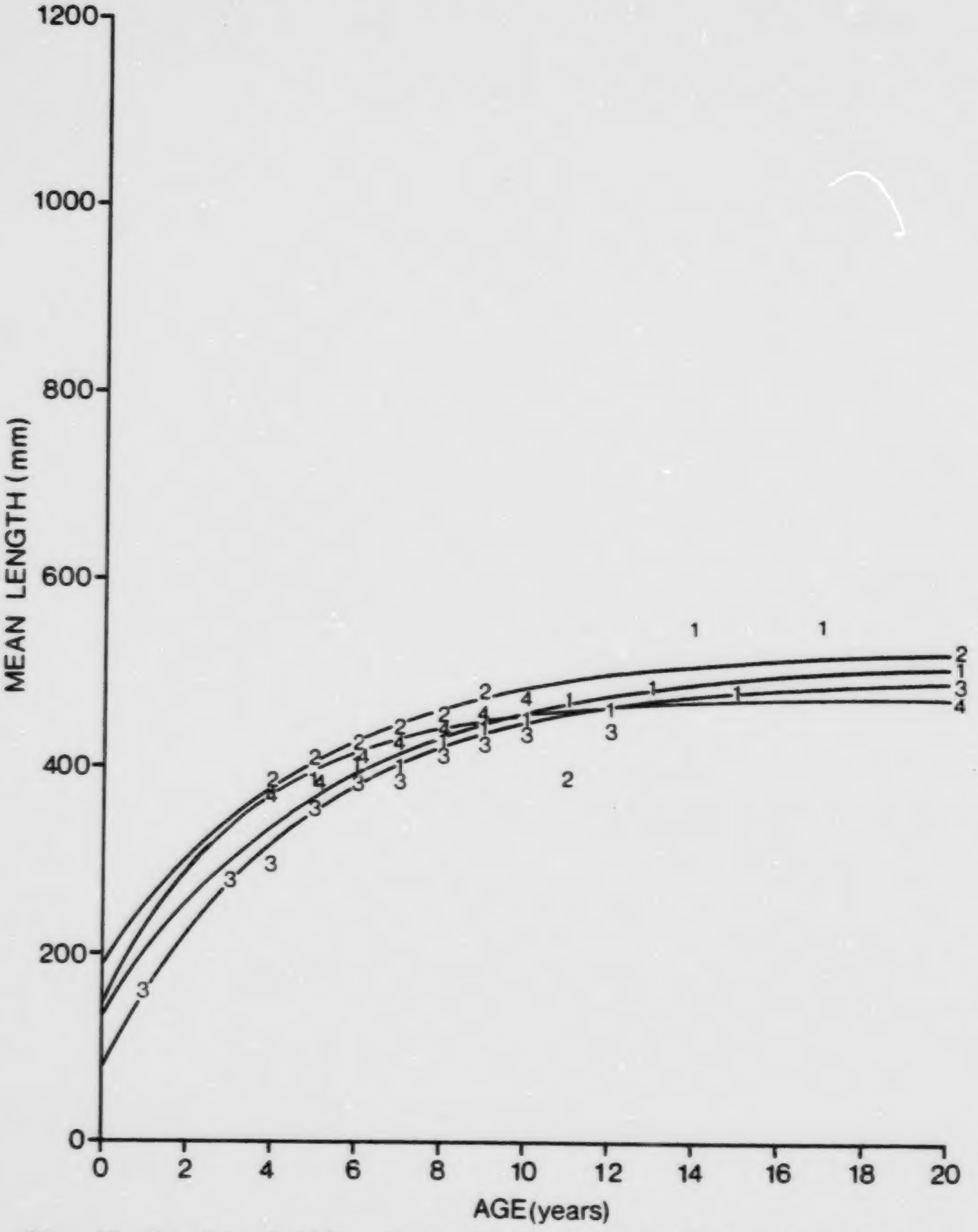

Fig. 43. Von Bertalanffy growth curves of whitefish from Max (1), MacPherson (2), Fairy Rock (3) and Pine (4) Lakes.

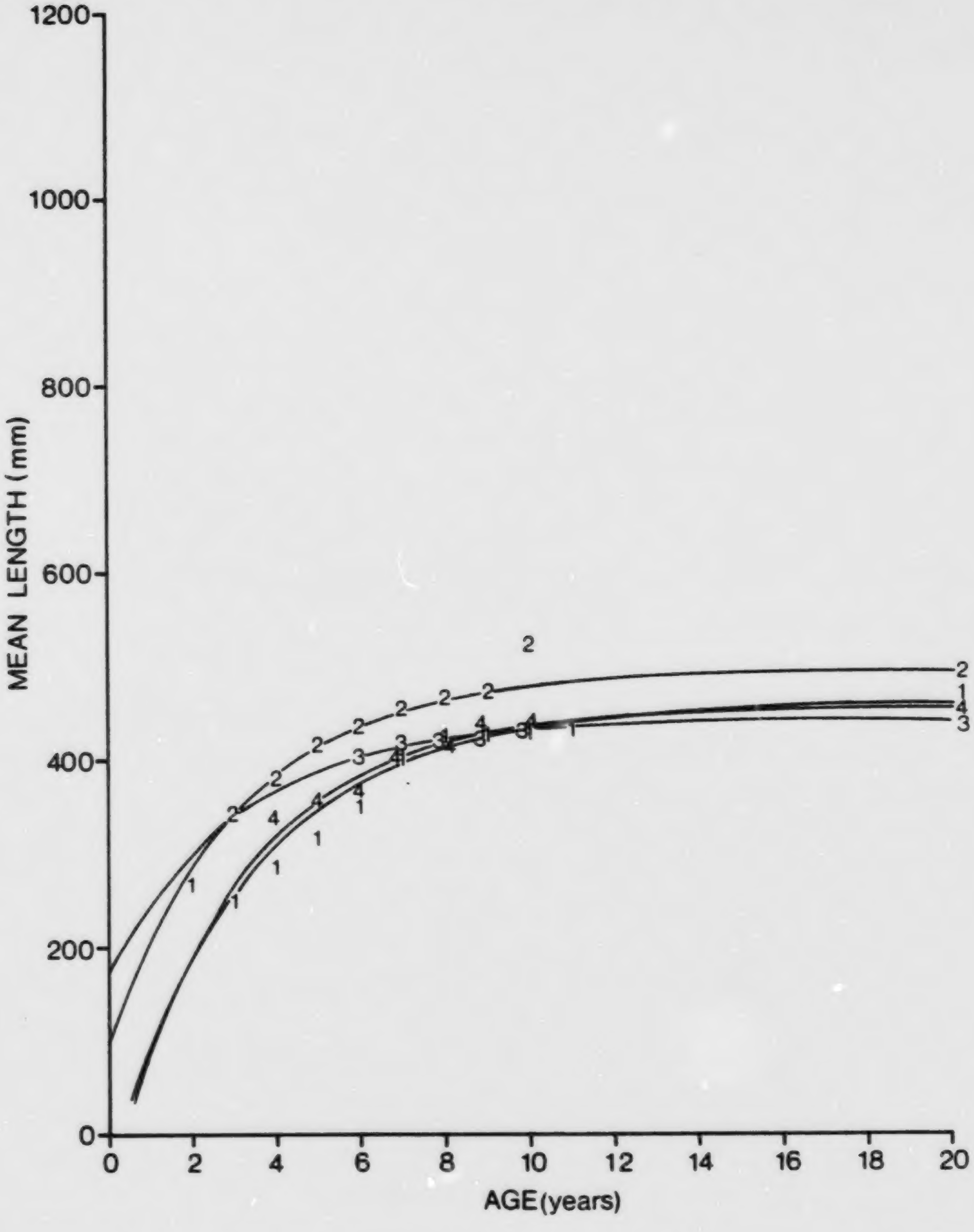

Fig. 44. Von Bertalanffy growth curves of whitefish from Mackerracher I (1), Bearhead (2), Aswapiswanan (3) and Mackerracher II (4) Lakes.

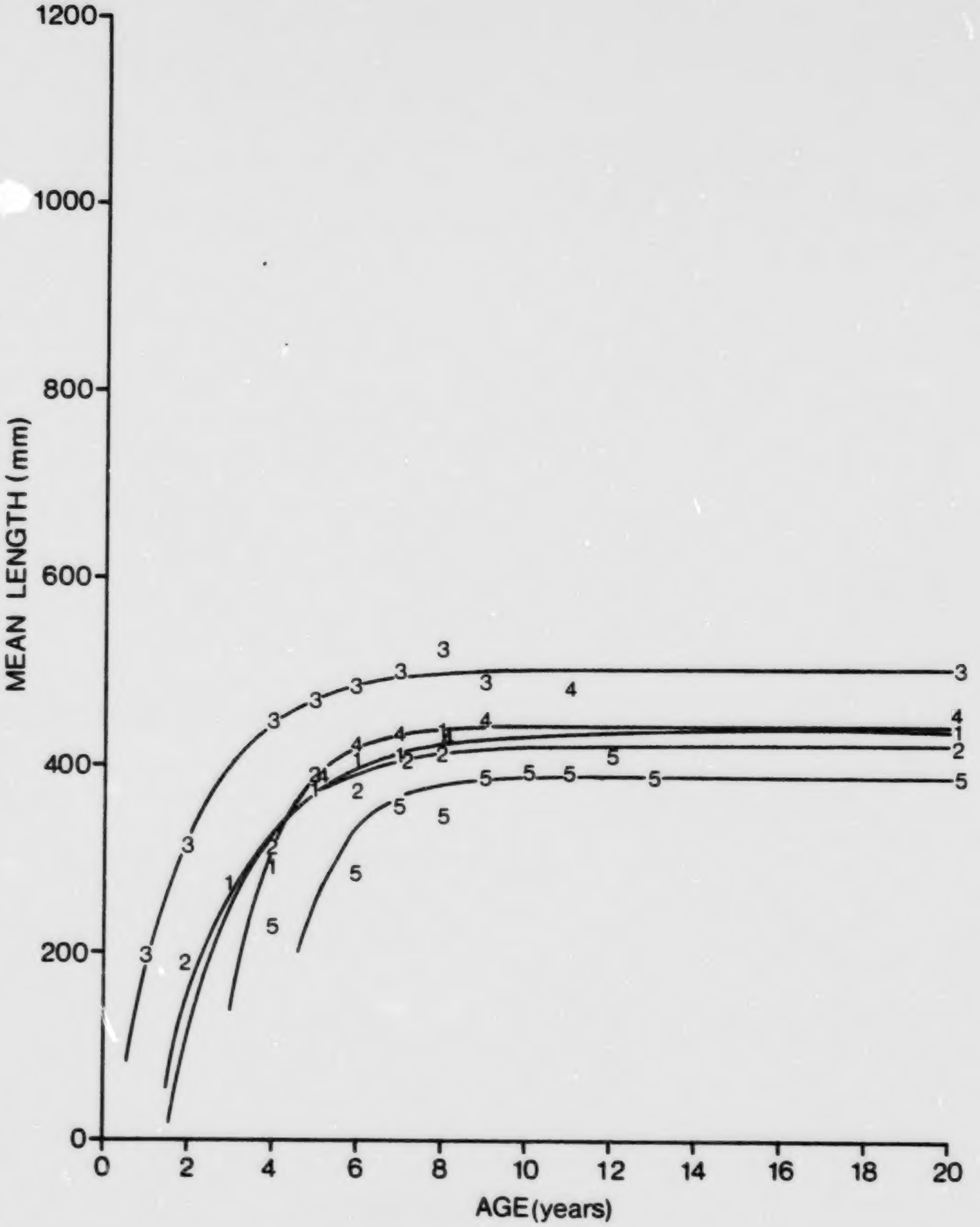

Fig. 45. Von Bertalanffy growth curves of whitefish from Numakoos (1), James (2), Semple (3), Whitefish (4) and Ankle (5) Lakes.

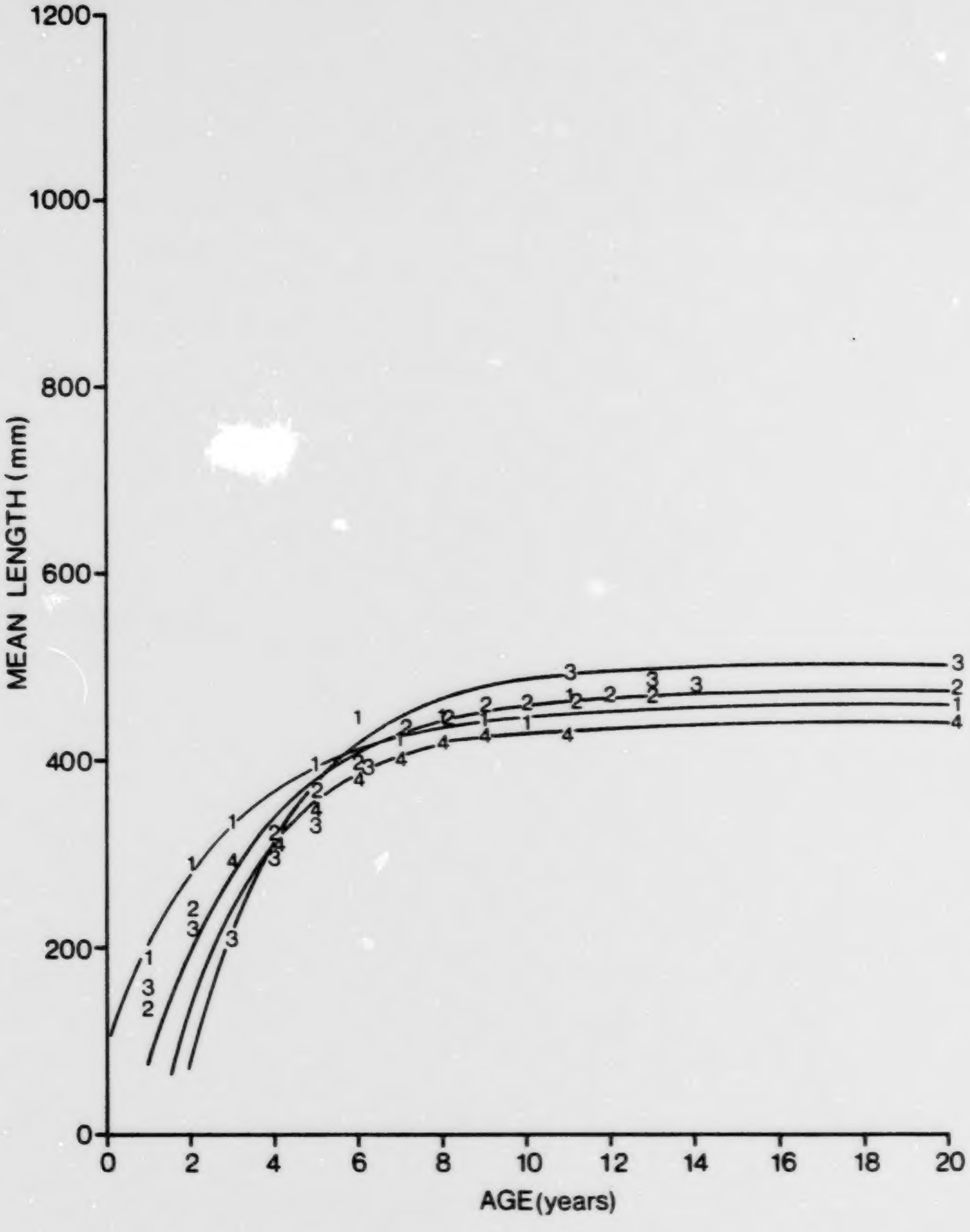

Fig. 46. Von Bertalanffy growth curves of whitefish from Willow (1), Enatik (2), Cuddle (3) and Denison (4) Lakes.

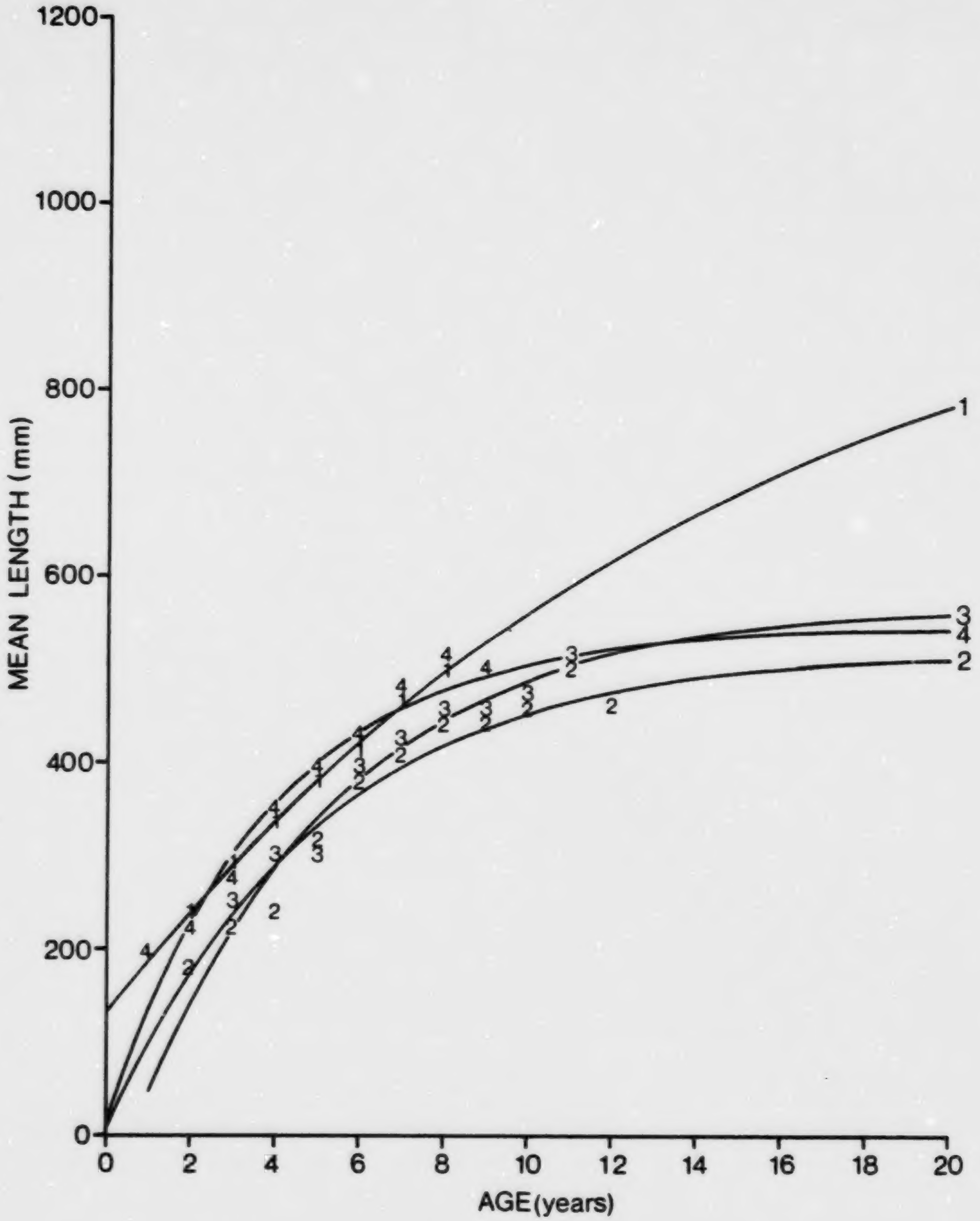

Fig. 47. Von Bertalanffy growth curves of walleyes from Mackerracher I (1), Aswapiswanan (2), Denison (3) and Enatik (4) Lakes.

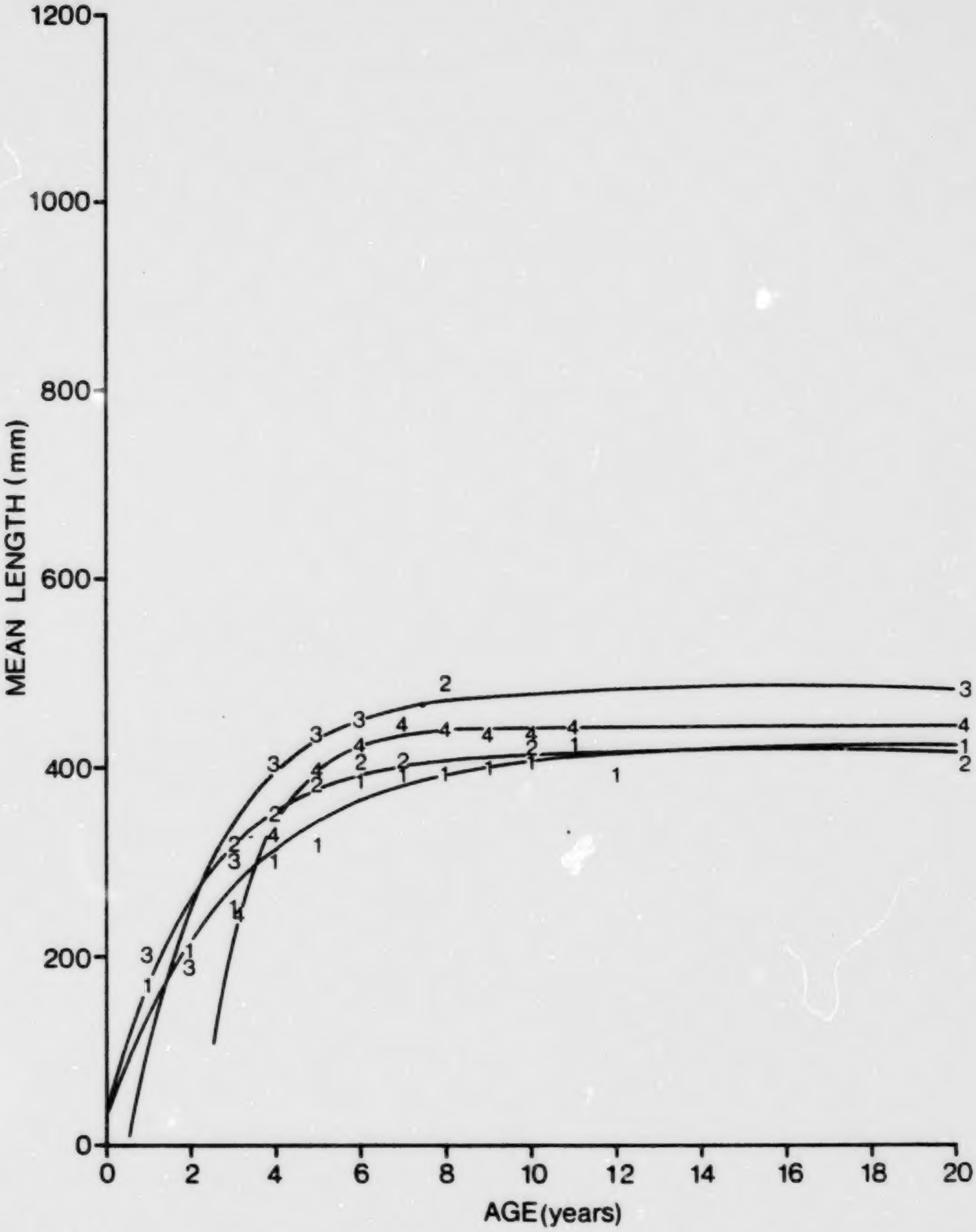

Fig. 48. Von Bertalanffy growth curves of walleyes from Wass (1), Bearhead (2), Cuddle (3) and Fairy Rock (4) Lakes.

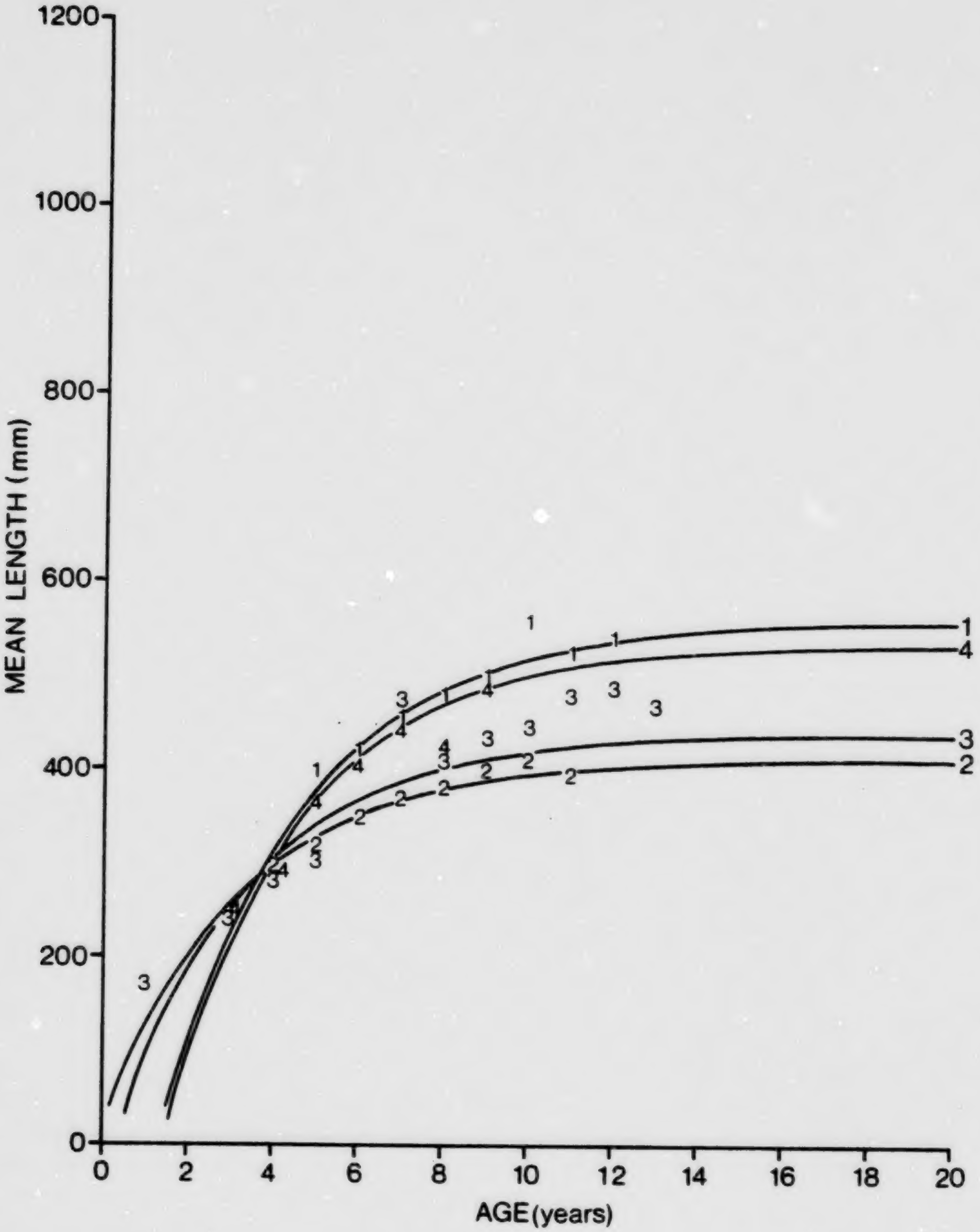

Fig. 49. Von Bertalanffy growth curves of walleyes from Max (1), Willow (2), Ankle (3) and Mackerracher II (4) Lakes.

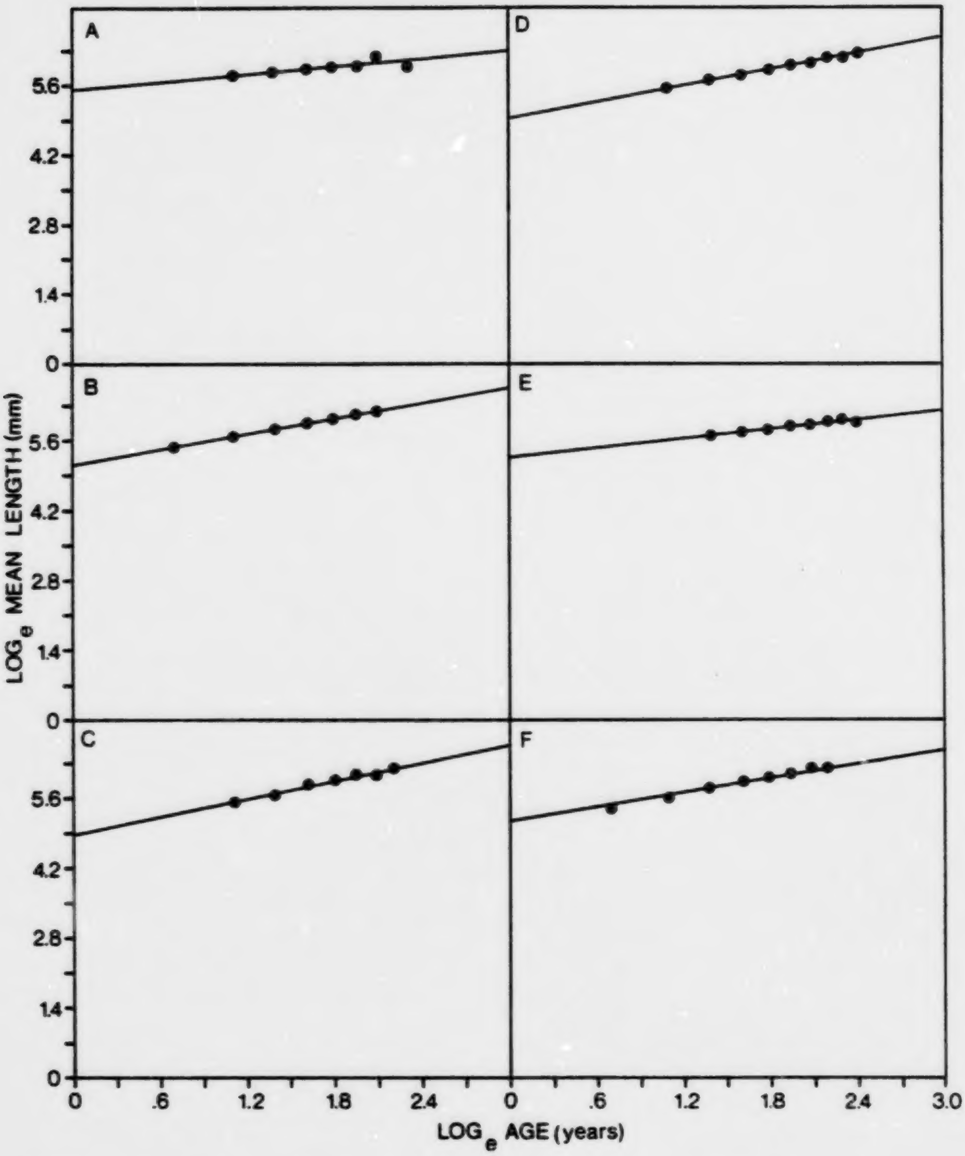

Fig. 50. Exponential growth curves of walleyes from Bearhead (A), Mackerracher I (B), Mackerracher II (C), Denison (D), Willow (E) and Enatik (F) Lakes.

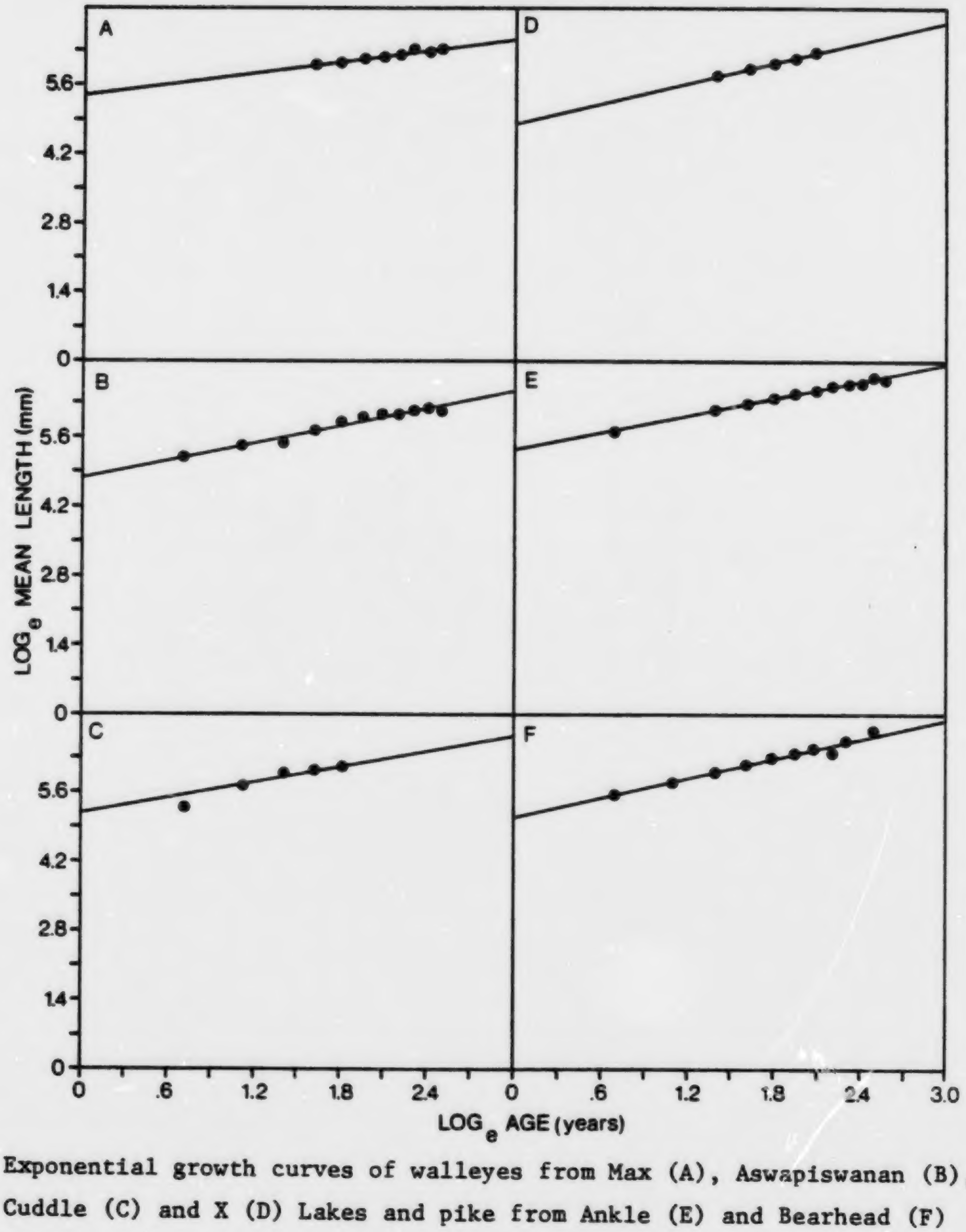

Fig. 51. Exponential growth curves of walleyes from Max (A), Aswapiswanan (B), Cuddle (C) and X (D) Lakes and pike from Ankle (E) and Bearhead (F) Lakes.

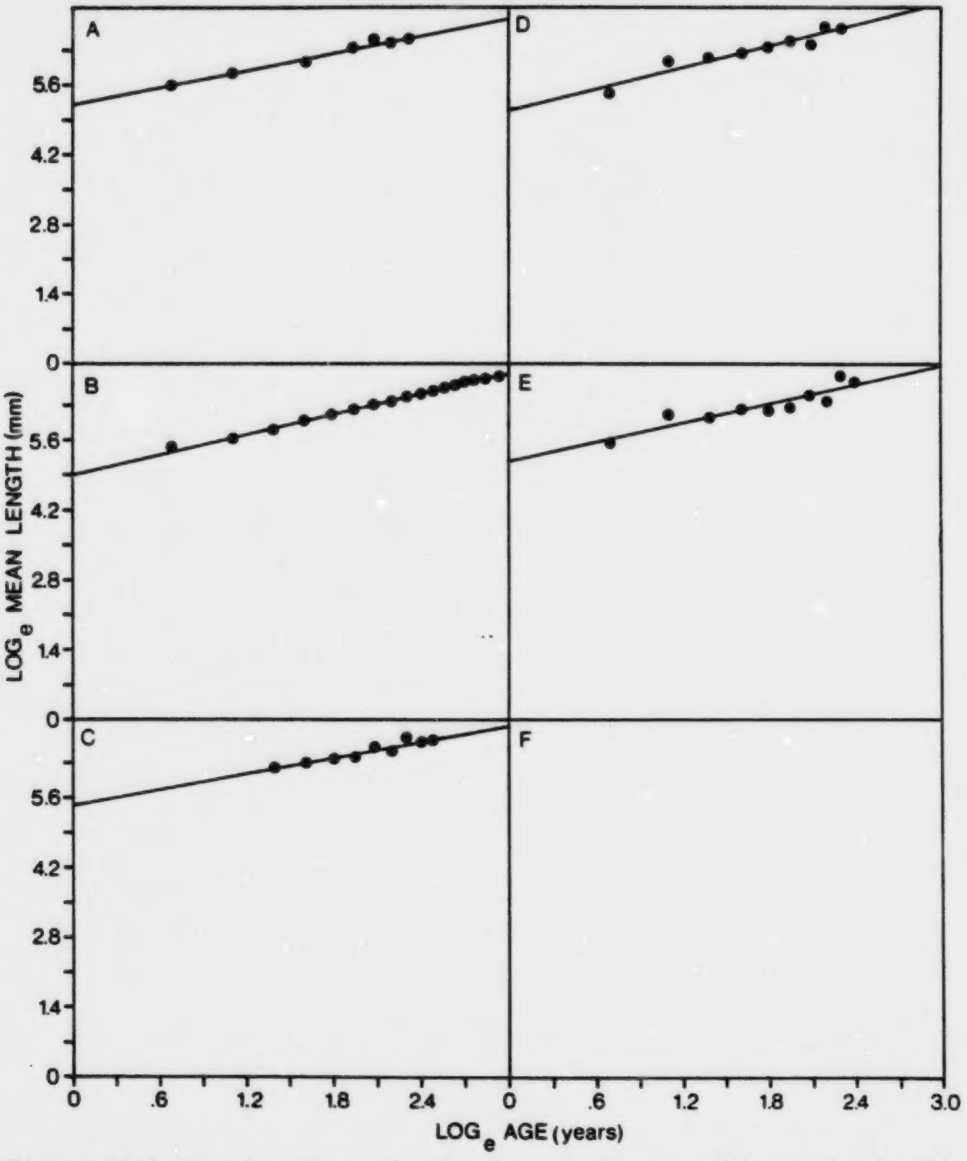

Fig. 52. Exponential growth curves of pike from MacPherson (A), MacBride (B), Fairy Rock (C), Semple (D) and Wass (E) Lakes.

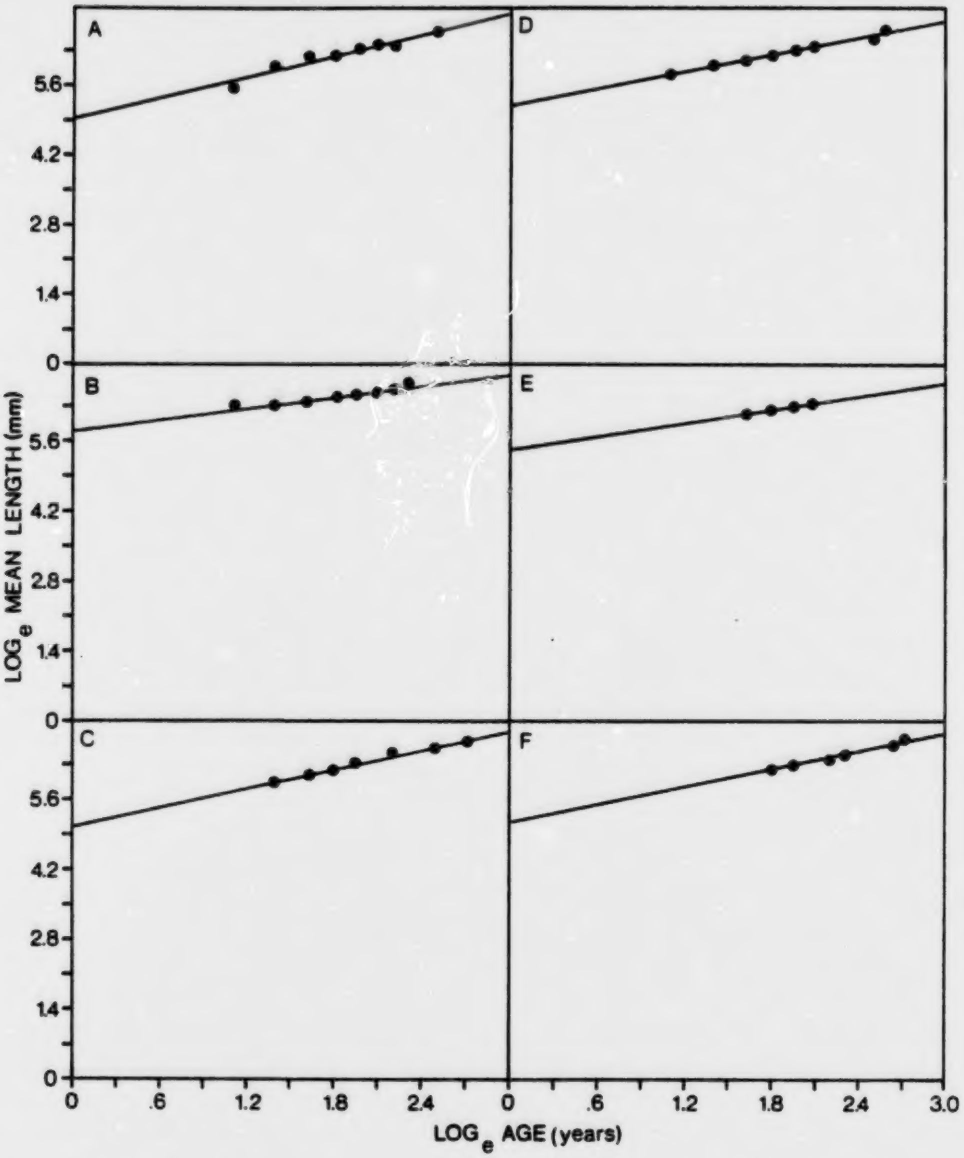

Fig. 53. Exponential growth curves of pike from Cuddle (A), Whitefish (B), Pine (C), Numakoos (D), James (E) and X (F) Lakes.

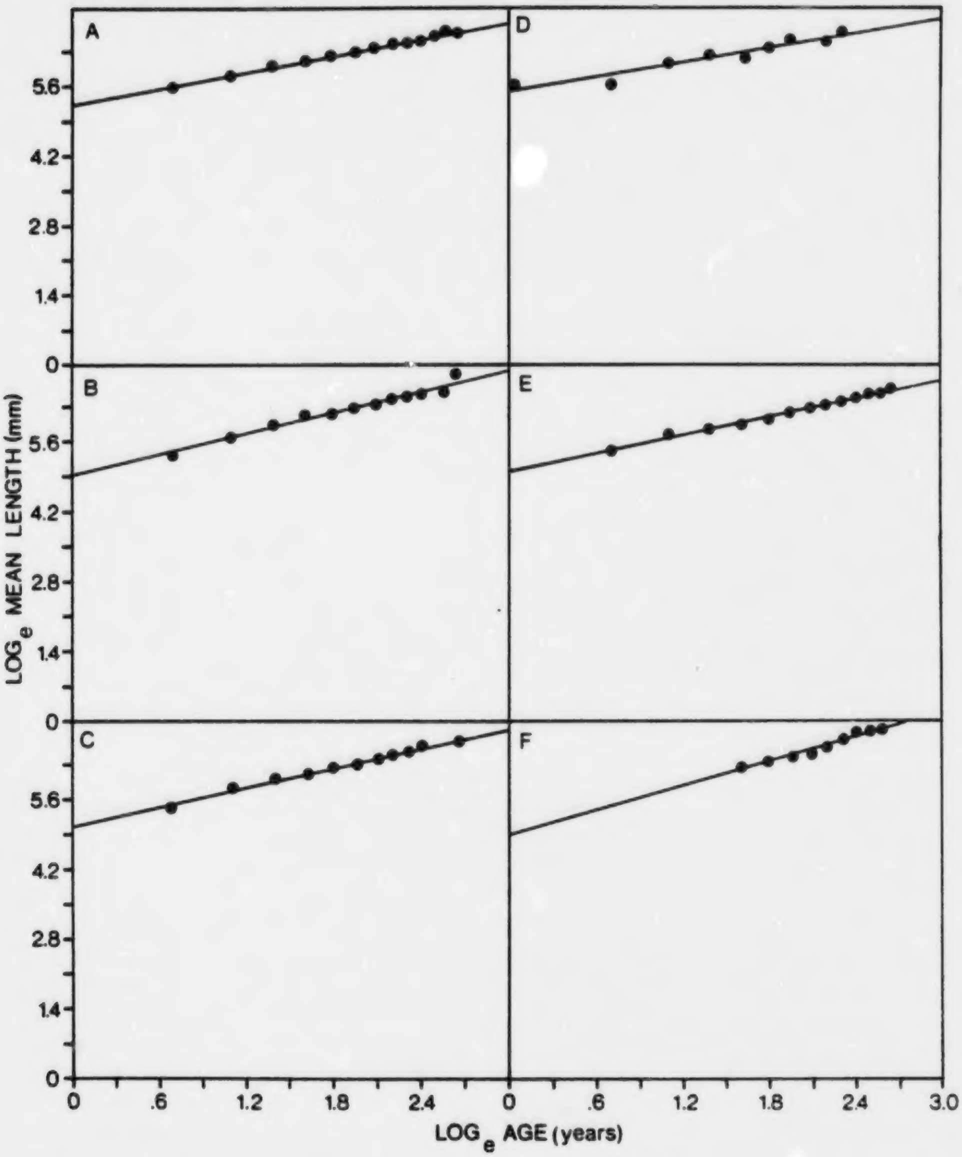

Fig. 54. Exponential growth curves of pike from Mackerracher I (A), Mackerracher II (B), Denison (C), Willow (D) , Enatik (E) and Max (F) Lakes.

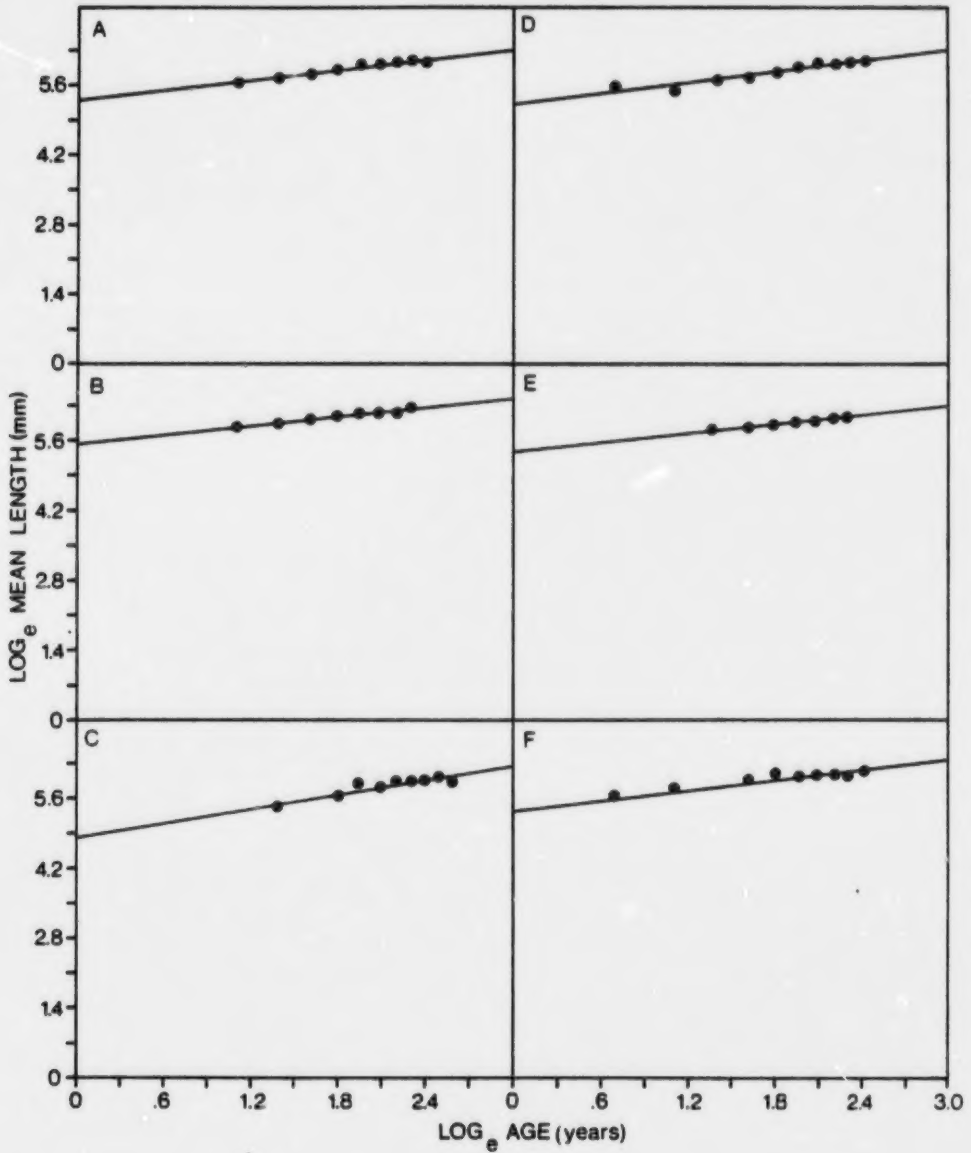

Fig. 55. Exponential growth curves of whitefish from Denison(A), Bearhead(B), Ankle(C), Mackerracher I(D), Mackerracher II (E) and Willow(F) Lakes.

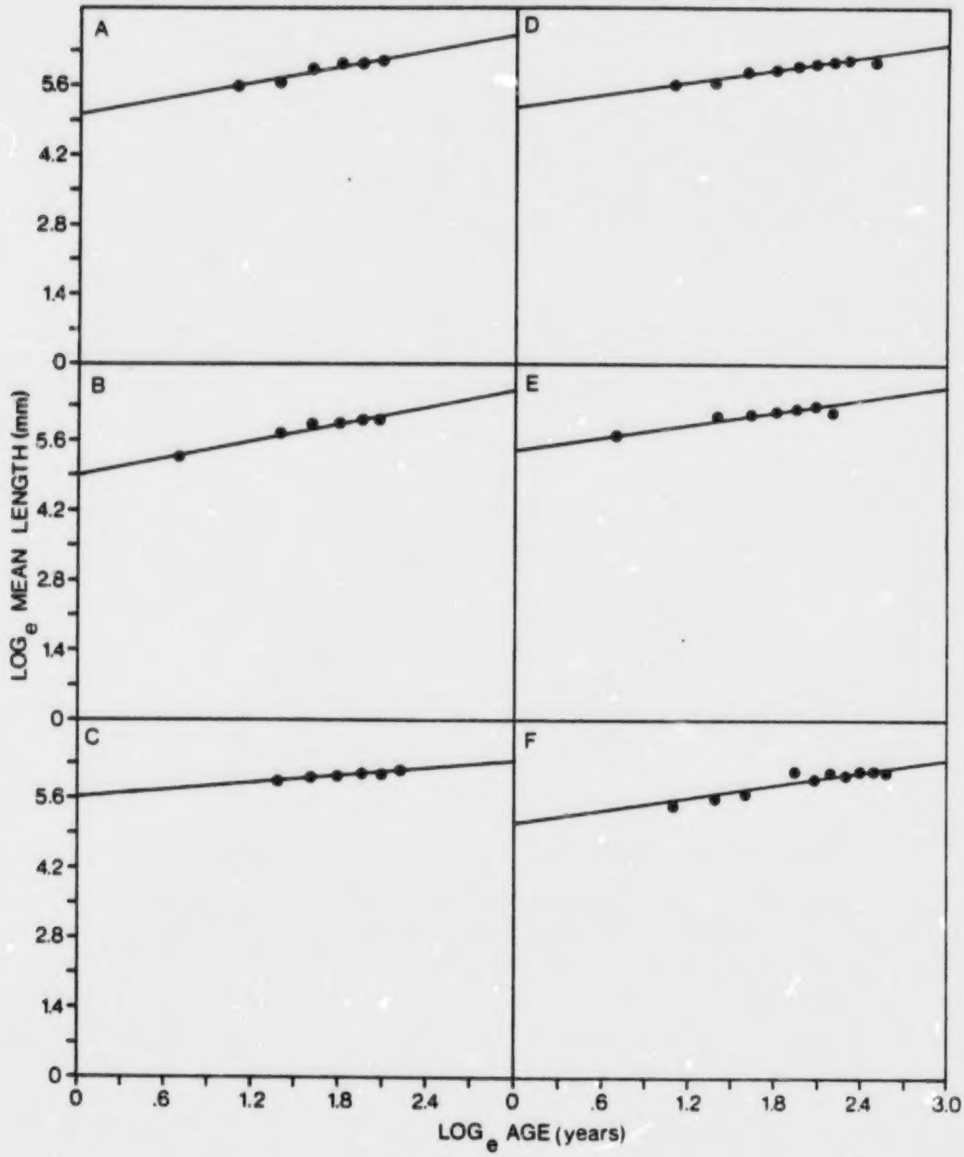

Fig. 56. Exponential growth curves of whitefish from Numakoos (A), James (B), MacPherson (C), Fairy Rock (D) and Semple (E) Lakes and of walleyes from Ankle (F) Lake.

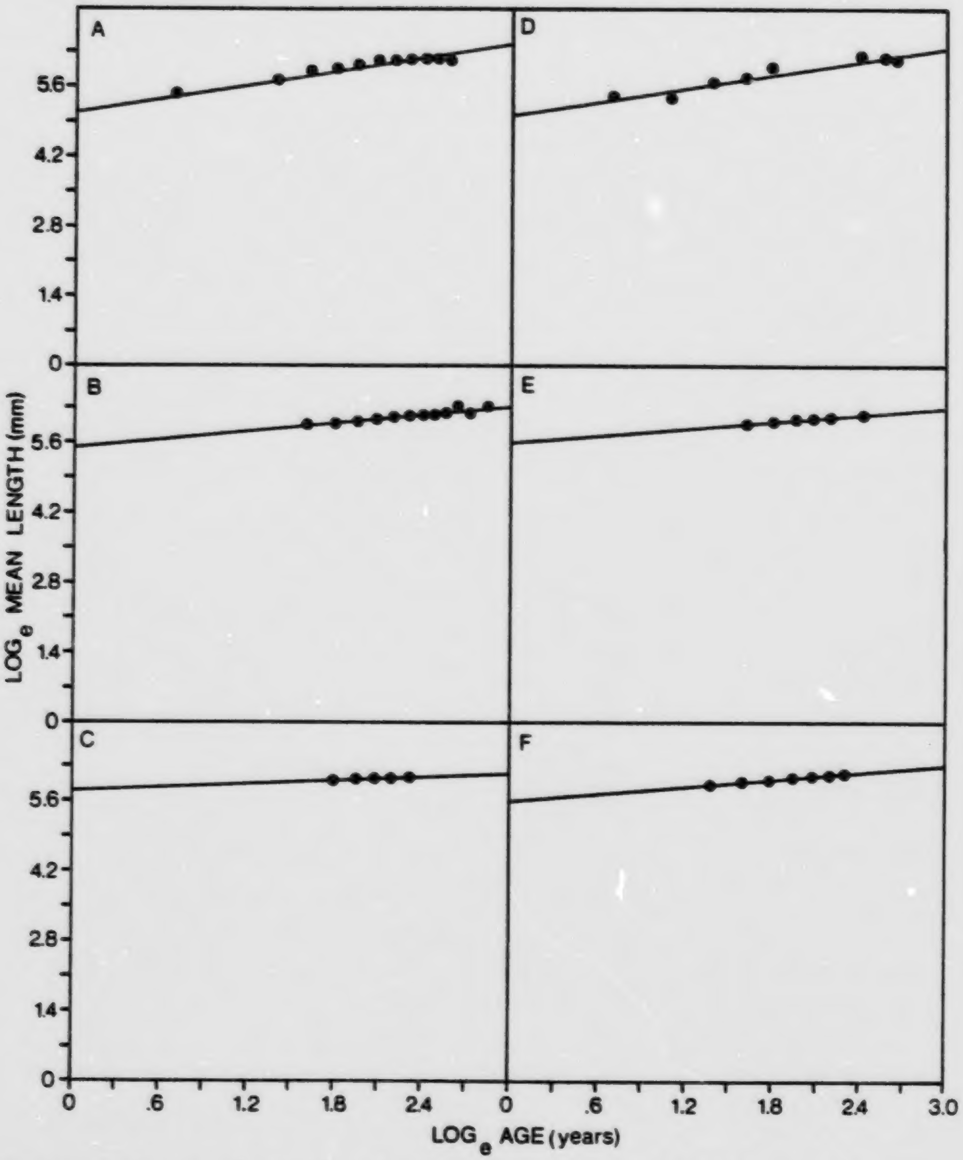

Fig. 57. Exponential growth curves of whitefish from Enatik(A), Max(B), Aswapiswanan(C), Cuddle(D), Whitefish(E) and Pine(F) Lakes.

Table 16 . Stepwise ANCOVA comparing Brody growth coefficients of pike.

Lake	Brody Growth coefficient	Groups	Comparison	Test F value and d.f.		Critical F value at P = 0.05	
				Slopes	Elevations	Slopes	Elevations
James	.727	1					
Cuddle	.416	2	James and Cuddle	9.02(1,5)	47.68(1,6)	6.61	5.99
Bearhead	.395						
Ankle	.361		Cuddle and Ankle	0.65(1,11)	10.47(1,12)	4.84	4.75
McPherson	.206	3	Cuddle and McPherson	26.15(1,8)	12.14(1,9)	5.32	5.12
Semple	.182						
Whitefish	.182						
Max	.179						
Wass	.156						
Fairy Rock	.143		McPherson & Fairy Rock	3.36(1,7)	7.59(1,8)	5.59	5.32
Mackerracher II	.136	4	McPherson & Mackerracher II	23.02(1,13)	50.52(1,14)	4.67	4.60
Numakoos	.110	5	Mackerracher II & Numakoos	23.42(1,14)	17.81(1,15)	4.60	4.54
Mackerracher I	.107		Numakoos & Mackerracher I	1.32(1,13)	3.38(1,14)	4.67	4.60
Enatik	.040	6	Numakoos & Enatik	226.50(1,17)	384.95(1,18)	4.45	4.41
MacBride	.033	7	Enatik & MacBride	14.55(1,27)	1312.58(1,28)	4.21	4.20
Denison	.030	8	MacBride & Denison	5.74(1,24)	647.07(1,25)	4.26	4.24
Willow	.013	9	Denison & Willow	74.76(1,16)	3458.24(1,17)	4.49	4.45

Table 17 . Stepwise ANCOVA comparing Brody growth coefficients of walleyes.

Lake	Brody Growth coefficient	Groups	Comparison	Test F value and d.f.		Critical F value at P = 0.05	
				Slopes	Elevations	Slopes	Elevations
Fairy Rock	.796	1	Fairy Rock & Cuddle	18.77(1,7)	.02(1,8)	5.59	5.32
Cuddle	.486	2					
Bearhead	.457		Cuddle & Bearhead	0.13(1,6)	5.96(1,7)	5.99	5.59
Wass	.321	3	Cuddle and Wass	7.76(1,12)	1.82(1,13)	4.75	4.67
Mackerracher II	.316						
Ankle	.315						
Willow	.303						
Max	.297						
Enatik	.258		Wass and Enatik	3.68(1,14)	41.90(1,15)	4.60	4.54
Denison	.205	4	Wass and Denison	14.85(1,15)	112.00(1,16)	4.54	4.49
Aswapiswanan	.200		Denison & Aswapiswanan	0.04(1,15)	7.70(1,16)	4.54	4.49
Mackerracher I	.067	5	Denison & Mackerracher I	54.96(1,12)	118.98(1,13)	4.75	4.67

Table 18. Stepwise ANCOVA comparing Brody growth coefficients of whitefish.

Lake	Brody Growth coefficient	Groups	Comparison	Test F value and d.f. Slopes	Test F value and d.f. Elevations	Critical F value at P = 0.05 Slopes	Critical F value at P = 0.05 Elevations
Ankle	.880						
Whitefish	.864						
Semple	.558	1					
James	.545						
Numakoos	.525		Ankle and Numakoos	2.19(1,5)	0.73(1,6)	6.61	5.99
Denison	.427		Ankle and Denison	9.97(1,8)	0.56(1,9)	5.32	5.12
Cuddle	.400						
Enatik	.355	2					
Willow	.332						
Aswapiswanan	.322						
Mackerracher II	.322		Denison & Mackerracher II	2.71(1,9)	1.37(1,10)	5.12	4.96
Bearhead	.317		Denison & Bearhead	11.54(1,11)	0.56(1,12)	4.84	4.75
Mackerracher I	.290	3					
Pine	.284		Bearhead and Pine	1.10(1,9)	0.46(1,10)	5.12	4.96
Fairy Rock	.211	4	Bearhead and Fairy Rock	43.88(1,12)	91.13(1,13)	4.75	4.67
McPherson	.204						
Max	1.87		Fairy Rock and Max	1.80(1,13)	2.26(1,14)	4.67	4.60

Table 19. Age-specific maturity frequencies (%) of walleyes, whitefish and pike used to derive maturity curves listed on Table 20.

Species	Age (years)	Lake												
		Wass	Mackerracher I	Mackerracher II	Bearhead	Aswapiswanan	Willow	Cuddle	Fairy Rock	Enatik	Semple	MacBride	Ankle	Denison
walleye	3				42.9					26.7				
	4		27.3		57.1			58.6	20.0	77.7				
	5	44.4	66.6		62.8	50.0	18.2	45.5	75.6	98.0				
	6	78.3	88.8		72.2	66.7	78.6	75.0	82.2					
	7	95.9	98.0		98.0	94.1	92.3	98.0	90.0					
	8	98.9				95.5	95.7							
	9					97.2								
whitefish	4		33.3											33.3
	5		49.0						50.0					68.8
	6		66.6						66.7					90.5
	7		96.3						87.5				66.6	97.9
	8								90.9				75.0	
	9												98.0	
pike	3									16.7				
	4		50.0	25.0						40.0	66.7	7.1		
	5		69.6	83.3				55.0		76.0	78.3	33.3		
	6		93.4	78.1				45.9		82.4	98.0	64.0		
	7		98.8	97.6				70.4				87.5		
	8							80.0				96.3		

Table 20. Maturity curves of walleyes, pike and whitefish.

Species	Lake	Maturity curve $-\log_e\left(\frac{k-y}{y}\right) = a + b\ .\ \text{age}$	Correlation coefficient	Age at 50% mature (years)	Abrasov's mean age of maturity (years)	Test F value and d.f.
walleye	Aswapiswanan	$Y = -4.605 + 0.945X$	0.955	4.87	5.94	31.08(1,3)
	Bearhead	$Y = -1.414 + 0.396X$	0.871	3.57	4.65	80.71(1,2)
	Mackerracher I	$Y = -7.381 + 1.600X$	0.999	4.61	5.17	789.51(1,2)
	Wass	$Y = -8.249 + 1.604X$	0.998	5.14	5.85	564.66(1,2)
	Willow	$Y = -8.408 + 1.501X$	0.949	5.60	6.15	18.03(1,2)*
	Cuddle	$Y = -5.262 + 1.191X$	0.848	4.42	5.21	5.14(1,2)*
	Fairy Rock	$Y = -5.264 + 1.115X$	0.919	4.72	5.32	10.90(1,2)*
	Enatik	$Y = -8.427 + 2.451X$	0.999	3.44	3.96	485.32(1,1)
Pike	Bearhead	$Y = -7.614 + 1.707X$	0.980	4.46	5.00	48.29(1,2)
	Mackerracher I	$Y = -6.307 + 1.505X$	0.988	4.19	4.87	83.02(1,2)
	Mackerracher II	$Y = -6.371 + 1.408X$	0.924	4.52	5.14	11.63(1,2)*
	Cuddle	$Y = -2.410 + 0.459X$	0.858	5.25	6.49	5.57(1,2)*
	Enatik	$Y = -4.784 + 1.101X$	0.978	4.35	4.85	43.24(1,2)
	Semple	$Y = -6.036 + 1.599X$	0.939	3.77	4.55	7.52(1,1)*
	MacBride	$Y = -8.070 + 1.429X$	0.997	5.65	6.09	539.31(1,3)
whitefish	Ankle	$Y = -10.913 + 1.601X$	0.919	6.82	7.58	5.41(1,1)*
	Mackerracher I	$Y = -6.122 + 1.259X$	0.939	4.86	5.55	14.79(1,2)*
	Denison	$Y = -6.744 + 1.508X$	1.000	4.47	5.07	6099.40(1,2)
	Fairy Rock	$Y = -4.066 + 0.816X$	0.980	4.98	6.05	49.56(1,2)

Ages at which 50% of the populations were mature were not related to the instantaneous maturity rates. Mean ages of maturity estimated by Abrasov's (1967) corrected formula (Lysack 1980) were consistently greater than mean ages of maturity estimated by the inflection point of the maturity curves (Table 20).

To determine whether or not significant differences existed among the instantaneous maturity rates of walleyes (Fig. 58), whitefish (Fig. 59) and pike (Fig. 60), stepwise ANCOVA was performed (Table 21). No significant differences existed among instantaneous rates or elevations of walleye maturity curves or of whitefish maturity curves. Pike from Cuddle Lake matured at a significantly slower rate than any of the other pike populations (Table 21).

Bimodal age compositions of walleyes existed in Ankle, Mackerracher II, Denison, Enatik, Aswapiswanan, Cuddle and Wass Lakes (Fig. 61). The oldest modal ages of walleyes occurred in Ankle and Aswapiswanan Lakes. Plurimodal age compositions of pike occurred in MacBride, Enatik, Mackerracher II, Fairy Rock and Willow Lakes. Modal ages of pike ranged from 5 to 9 years. Extremely platykurtic age distributions of pike occurred in MacBride and Enatik Lakes. All other pike age distributions were more leptokurtic (Fig. 62). Plurimodal age compositions of whitefish occurred in Fairy Rock, Willow Bearhead, Ankle and James Lakes. Age compositions of whitefish from Aswapiswanan, Denison, Semple, Whitefish, Max and McPherson Lakes were leptokurtic. Modal ages of whitefish ranged from five to seven years (Fig. 63). Evidence of plurimodality also exists in some of the age compositions comprised of less than 20 fish (Figs. 60-63).

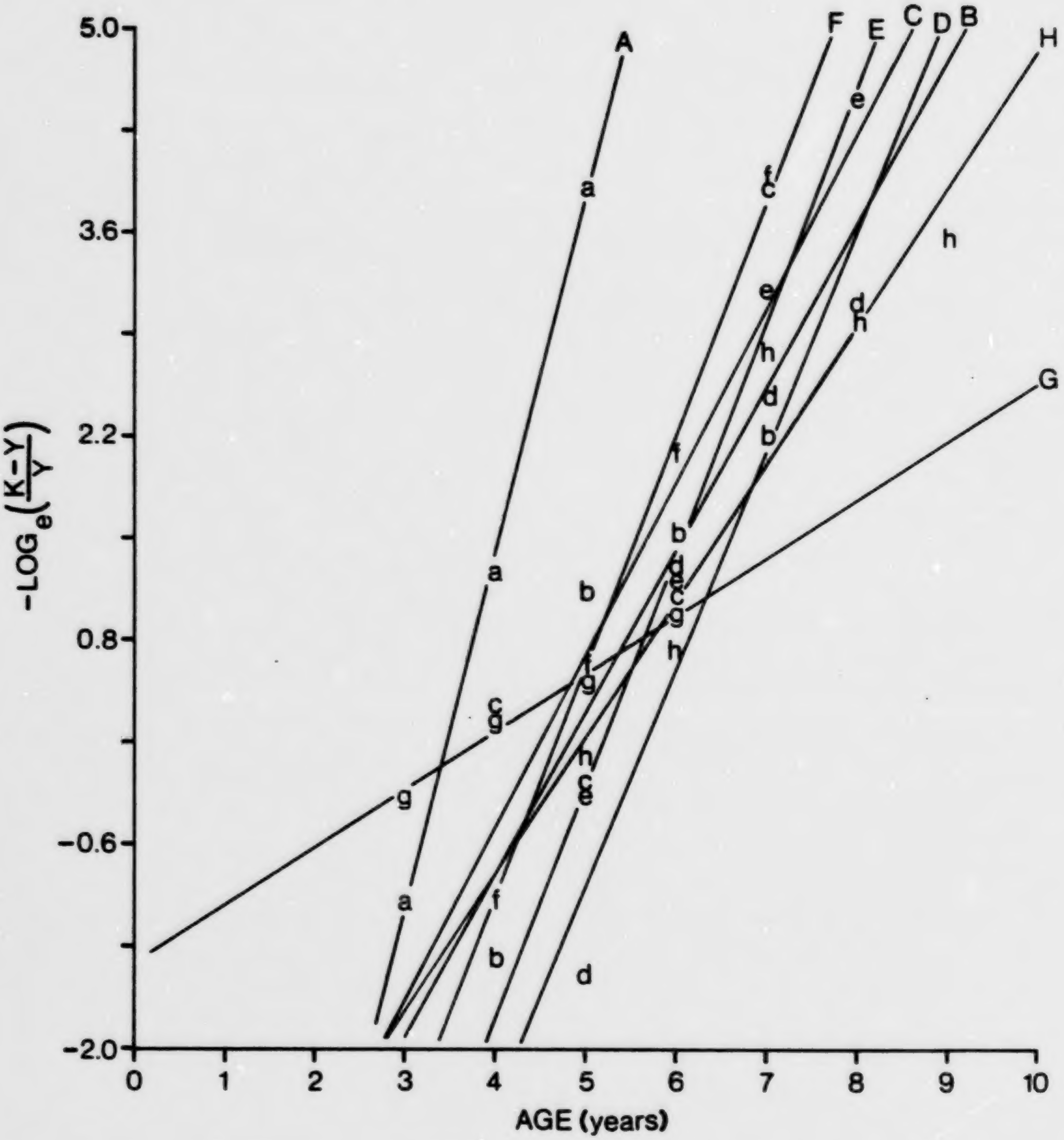

Fig. 58. Walleye maturity curves. Enatik-A, Fairy Rock-B, Cuddle-C, Willow-D, Wass-E, Mackerracher I-F, Bearhead-G, Aswapiswanan-H.

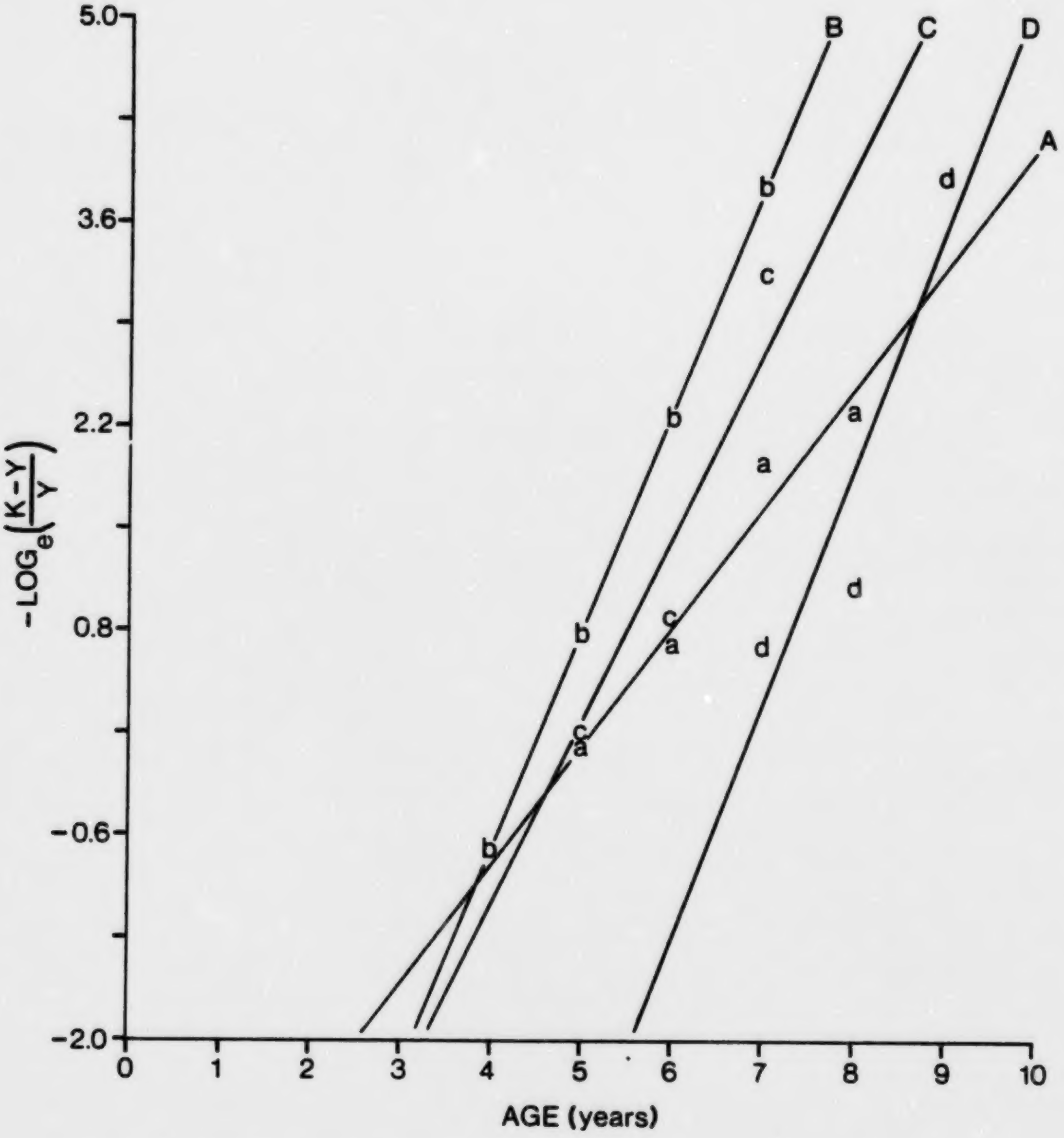

Fig. 59. Whitefish maturity curves. Fairy Rock-A, Denison-B, Mackerracher I-C, Ankle-D.

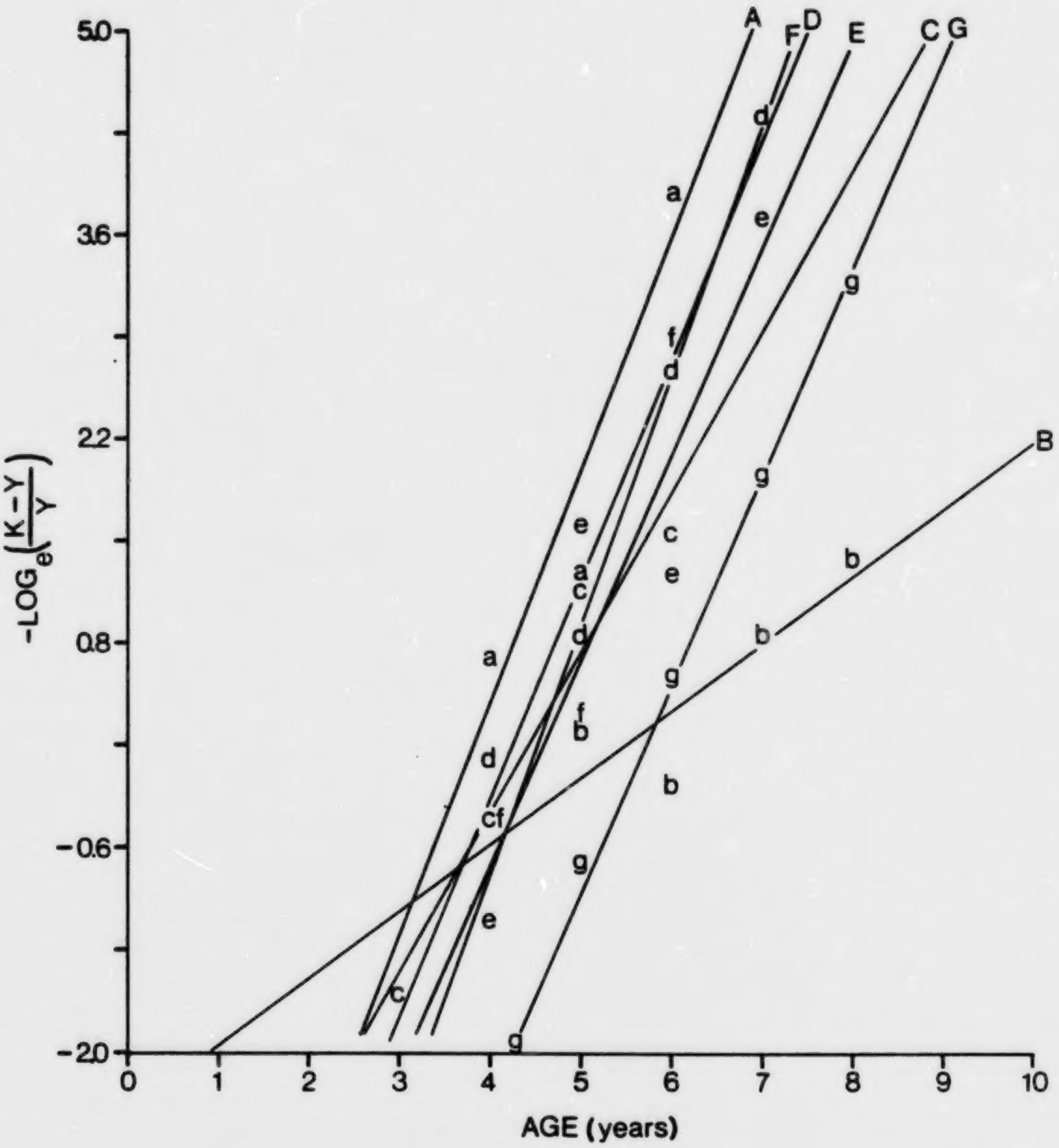

Fig. 60. Pike maturity curves. Semple-A, Cuddle-B, Enatik-C, Mackerracher I-D, Mackerracher II-E, Bearhead-F, MacBride-G.

Table 21., Stepwise ANCOVA comparing instantaneous maturity rates of walleyes, whitefish and pike.

Species	Lake	Instantaneous maturity rate	Comparison	Test F value and d.f.		Critical F value at P = 0.05	
				Slopes	Elevations	Slopes	Elevations
Walleye	Enatik	2.451					
	Wass	1.604					
	Mackerracher I	1.600					
	Willow	1.501					
	Cuddle	1.191					
	Fairy Rock	1.115					
	Aswapiswanan	0.945					
	Bearhead	0.396	Enatik and Bearhead	6.13(1,4)	2.63(1,5)	7.71	6.61
Whitefish	Ankle	1.601					
	Denison	1.508					
	Mackerracher I	1.259					
	Fairy Rock	0.816	Ankle and Fairy Rock	2.44(1,3)	1.83(1,4)	10.13	7.71
Pike	Bearhead	1.707					
	Semple	1.599					
	Mackerracher I	1.505					
	MacBride	1.429					
	Mackerracher II	1.408					
	Enatik	1.101	Bearhead and Enatik	4.15(1,4)	0.06(1,5)	7.71	6.61
	Cuddle	0.459	Bearhead and Cuddle	15.88(1,4)	3.14(1,5)	7.71	6.61

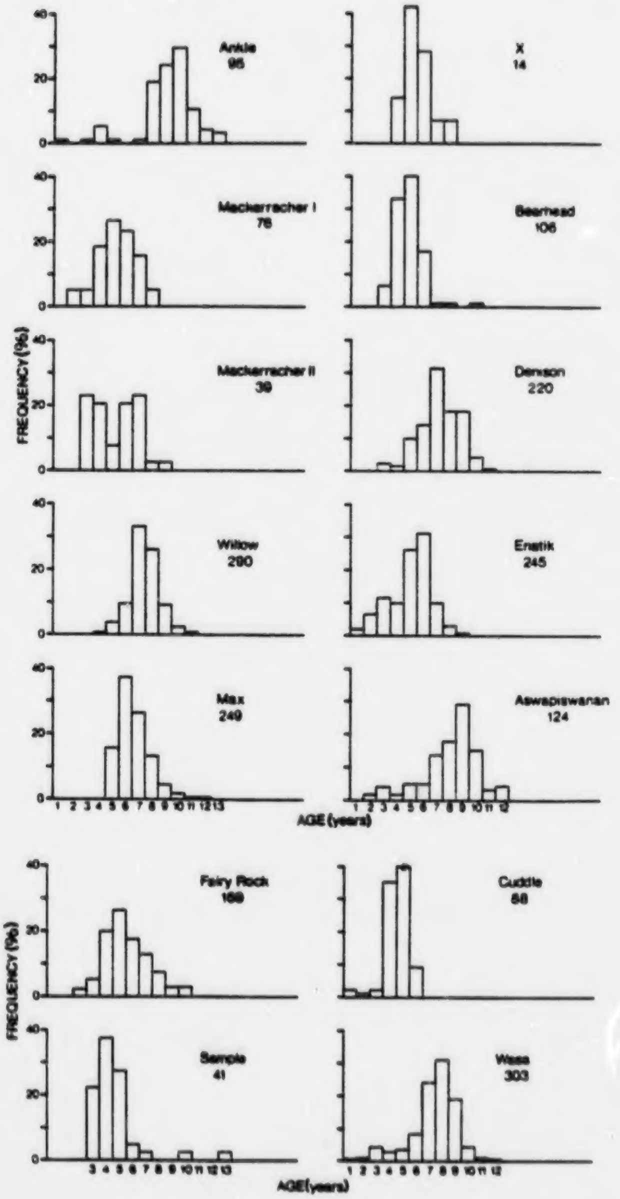

Fig. 61. Age compositions of walleyes. Sample sizes are under lake names.

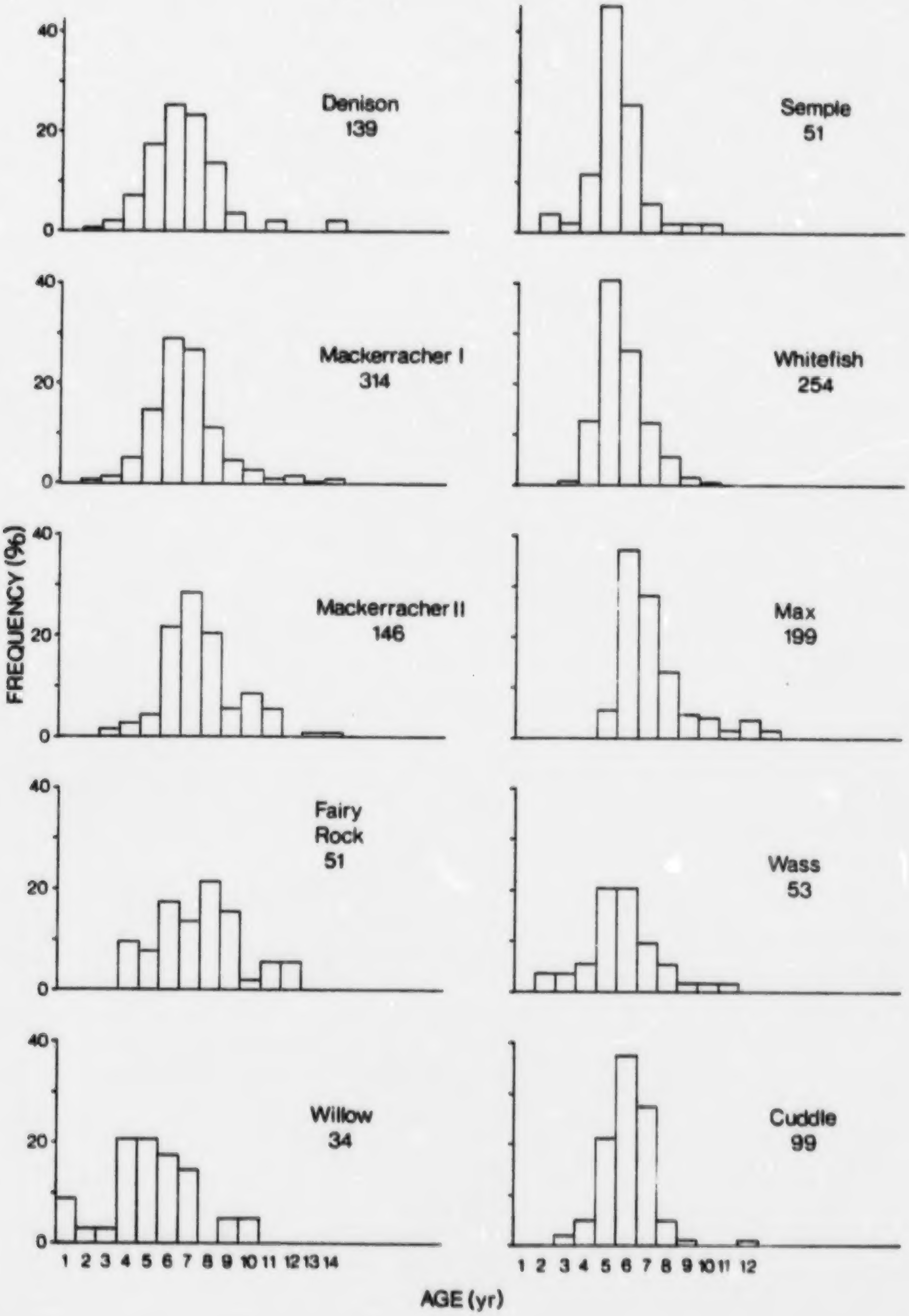

Fig. 62. Age compositions of pike. Sample sizes are under lake names.

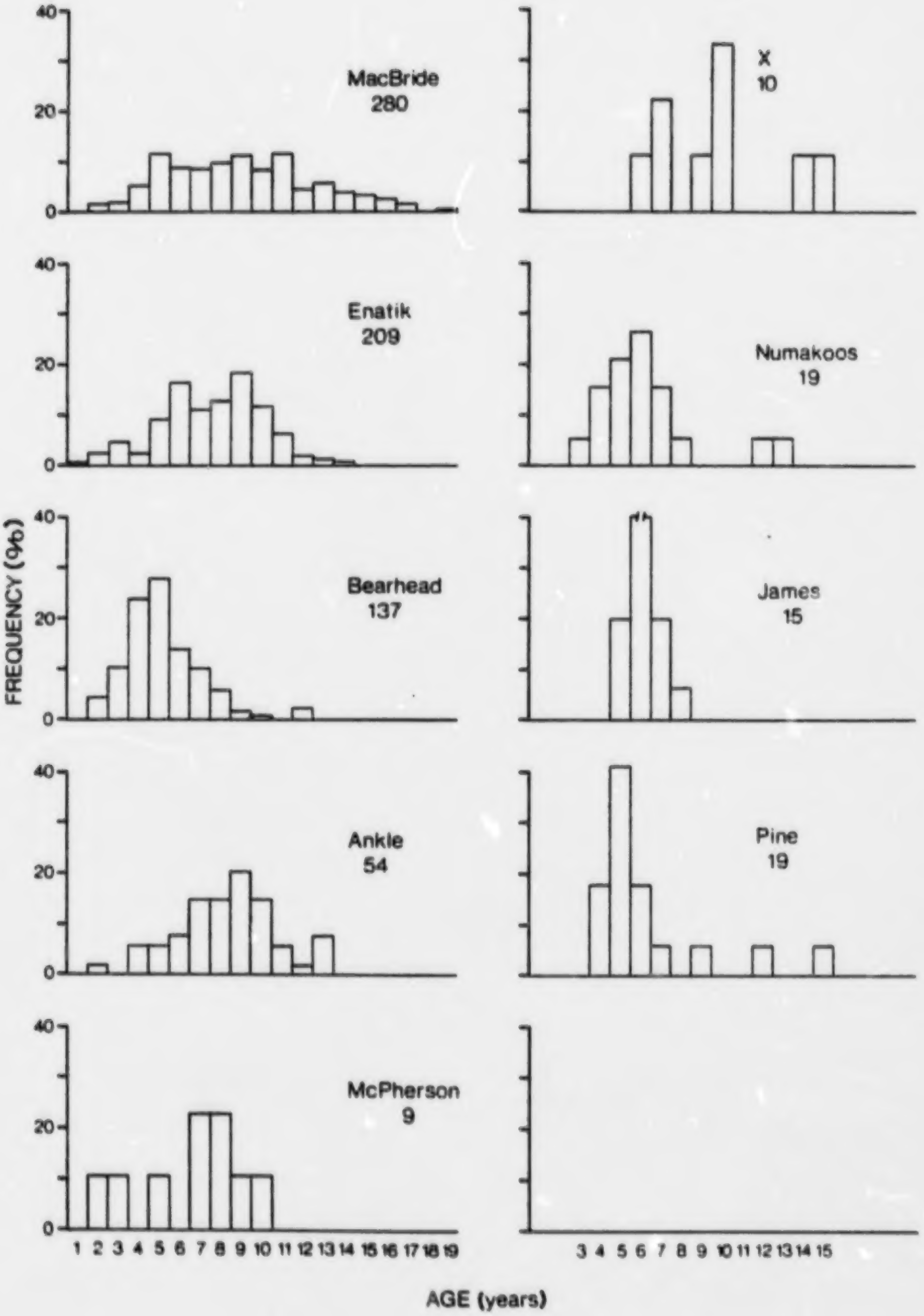

Fig. 62. continued.

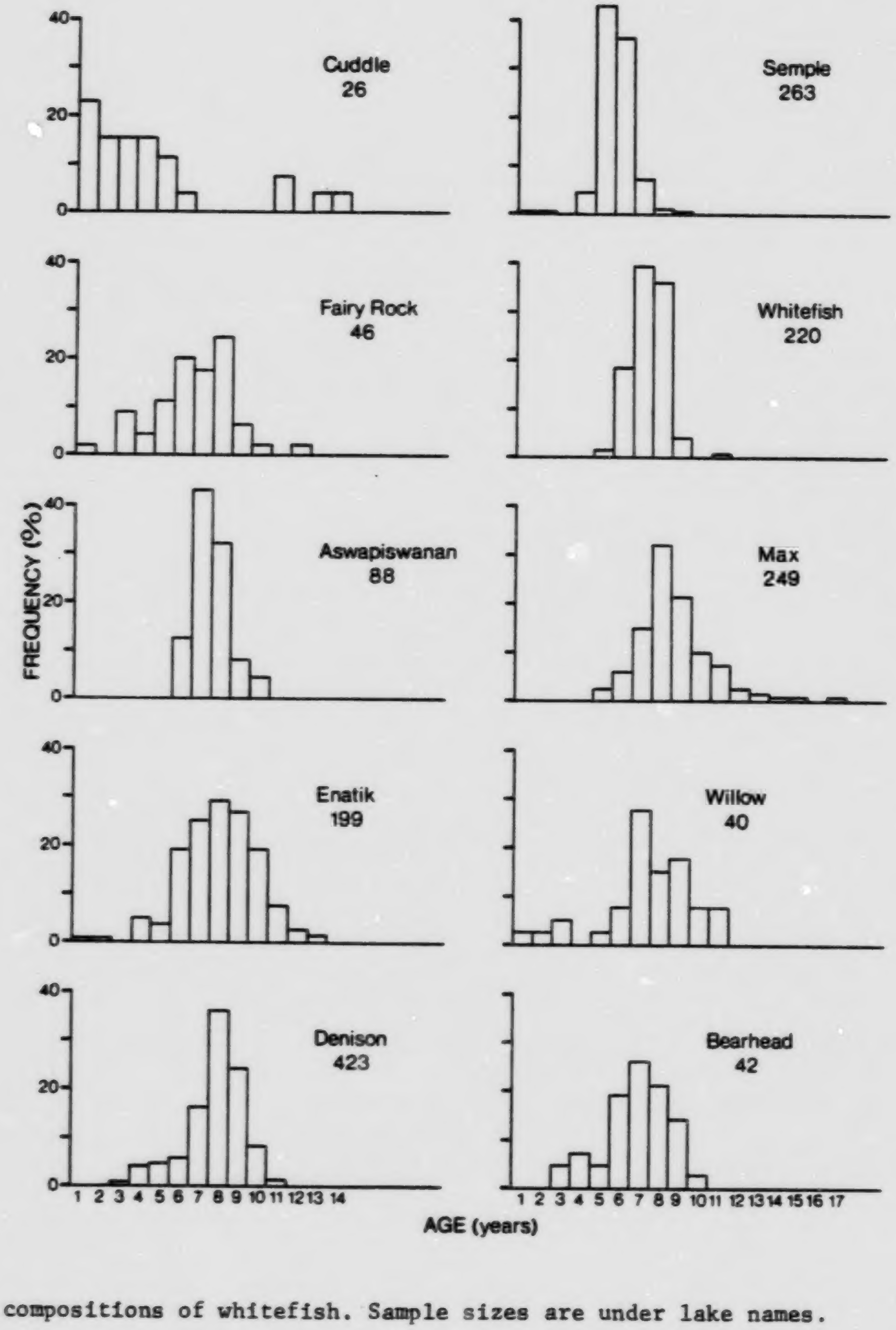

Fig. 63. Age compositions of whitefish. Sample sizes are under lake names.

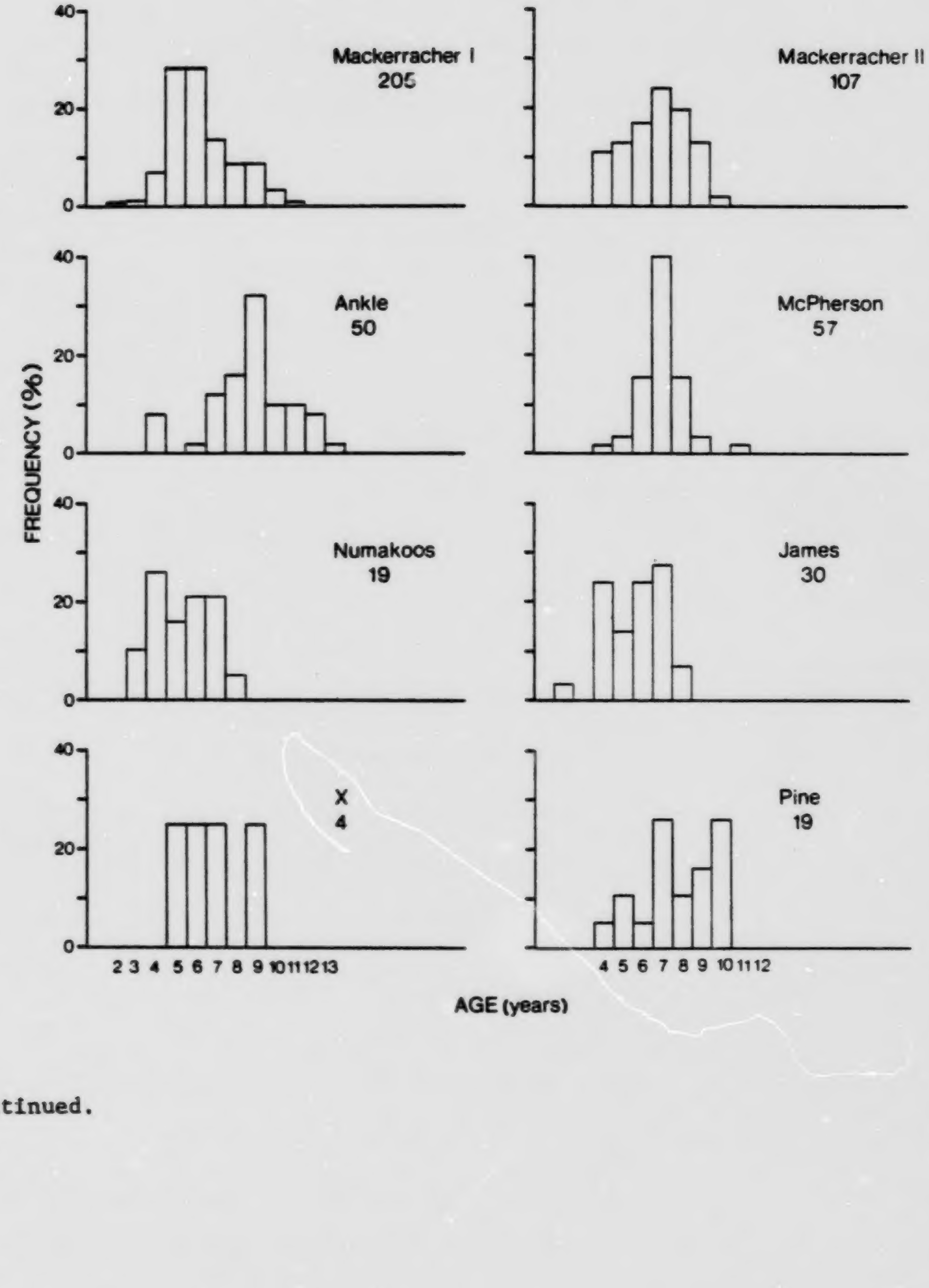

Fig. 63. continued.

Differences between instantaneous survival rates estimated from the descending limbs of catch curves (Figs. 64-68) by regression and the Robson-Chapman (1961) method were greater than 0.1 for only five walleye populations and five whitefish populations. However, the two estimates of survival differed by more than 0.1 for ten of the pike populations. Robson-Chapman estimates of annual mortality of walleyes, pike and whitefish ranged from 25% to 82%, 32% to 78% and 32% to 89%, respectively (Table 22).

Plots comparing scale ages to their respective mean spine ages and mean otolith ages of walleyes generally have the following characteristics in common:

a) less discrepancies among scale, spine and otolith ages exist at relatively young ages.

b) discrepancies between scale and spine ages, scale and otolith ages and spine and otolith ages all increased with increasing scale ages.

c) Mean spine ages were generally intermediate to those determined from scales and otoliths.

d) discrepancies among scale, spine and otolith ages tended to decrease at one or two of the relatively older scale ages.

e) Variance about mean spine and otolith ages was relatively high (Figs. 69 - 74).

Differences among pike scale ages and their respective mean opercular and mean fin ray ages were generally less than those of walleyes (Figs. 75 - 80). Mean opercular and fin ray ages of pike from Fairy Rock and Semple Lakes were generally lower than their respective scale ages (Figs. 75, 77).

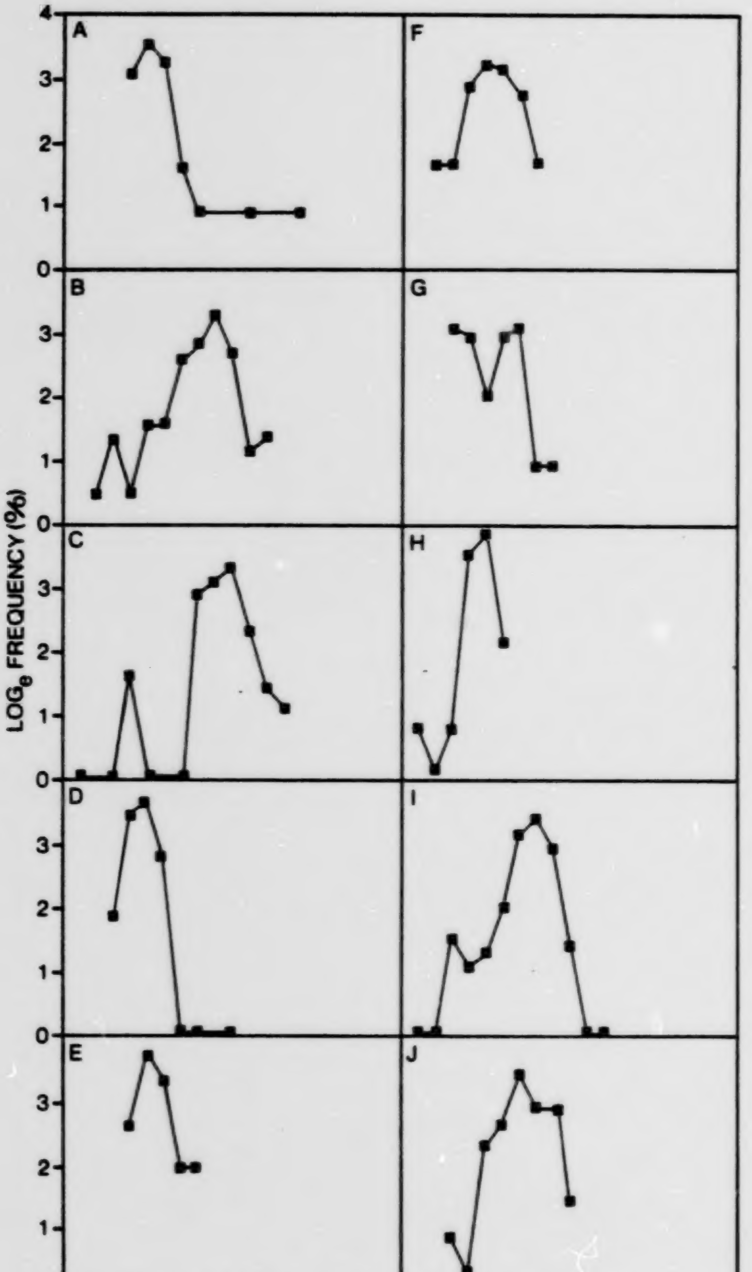

Fig. 64. Catch curves of walleyes from Semple(A), Aswapiswanan(B), Ankle(C), Bearhead(D), X(E), Mackerracher I(F), Mackerracher II(G), Cuddle(H), Wass(I) and Denison(J) Lakes.

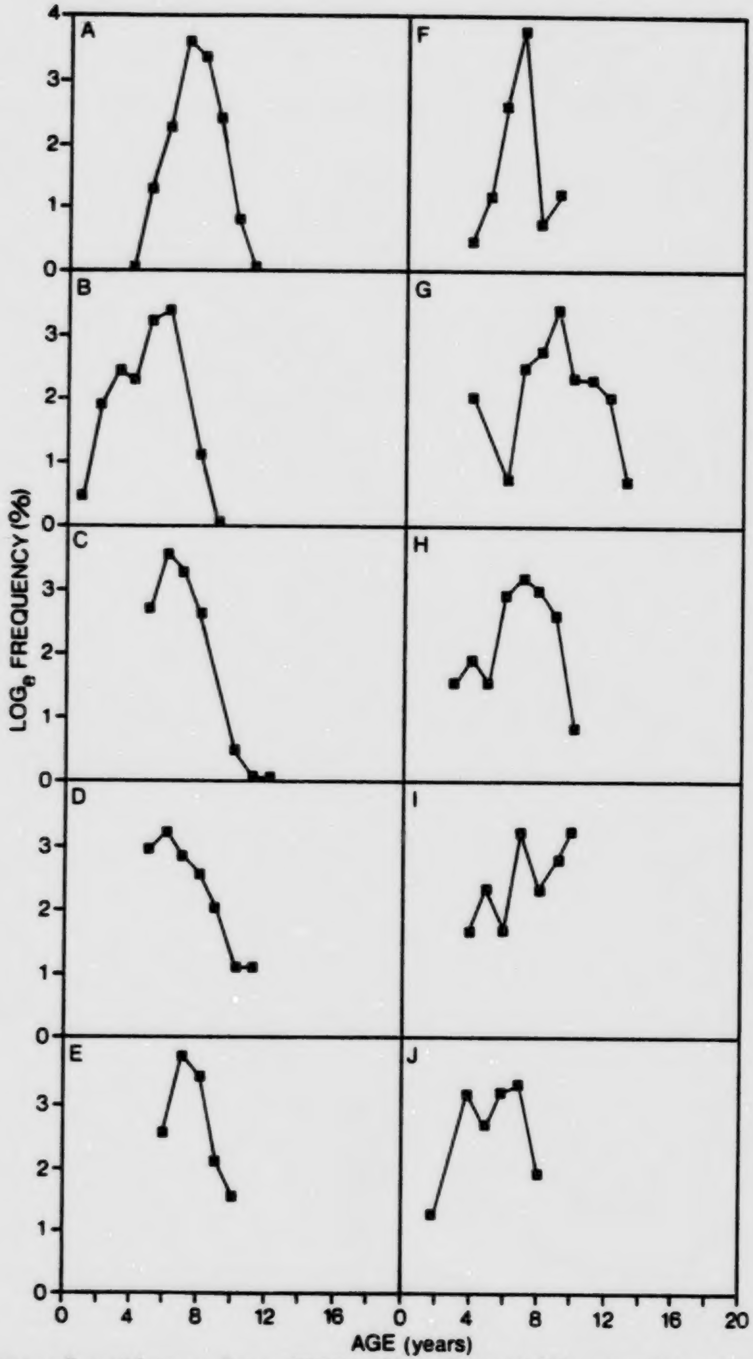

Fig. 65. Catch curves of walleyes from Willow(A), Enatik(B), Max(C) and Fairy Rock(D) Lakes and of whitefish from Aswapiswanan(E), MacPherson(F) Ankle(G), Bearhead(H), Pine(I) and James(J) Lakes.

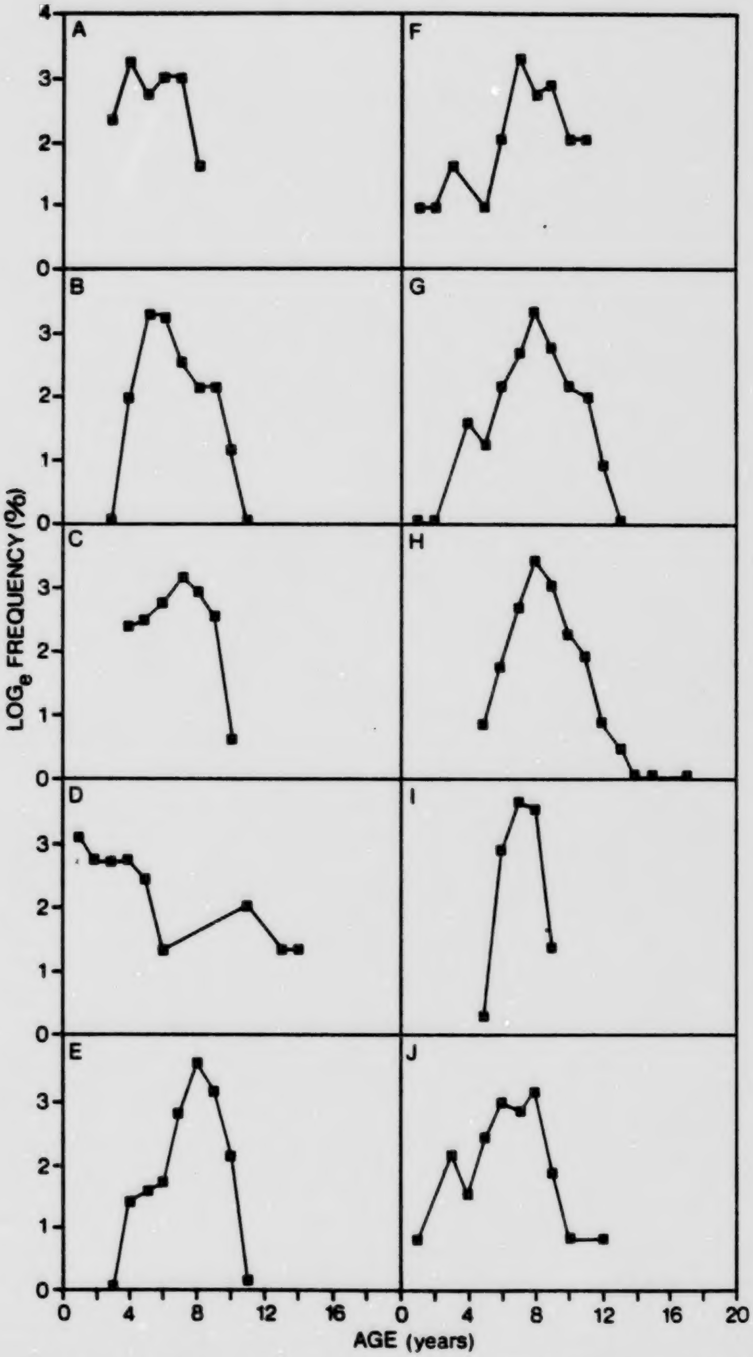

Fig. 66. Catch curves of whitefish from Numakoos(A), Mackerracher I(B), Mackerracher II(C), Cuddle(D), Denison(E), Willow(F), Enatik(G), Max(H), Whitefish(I) and Fairy Rock(J) Lakes.

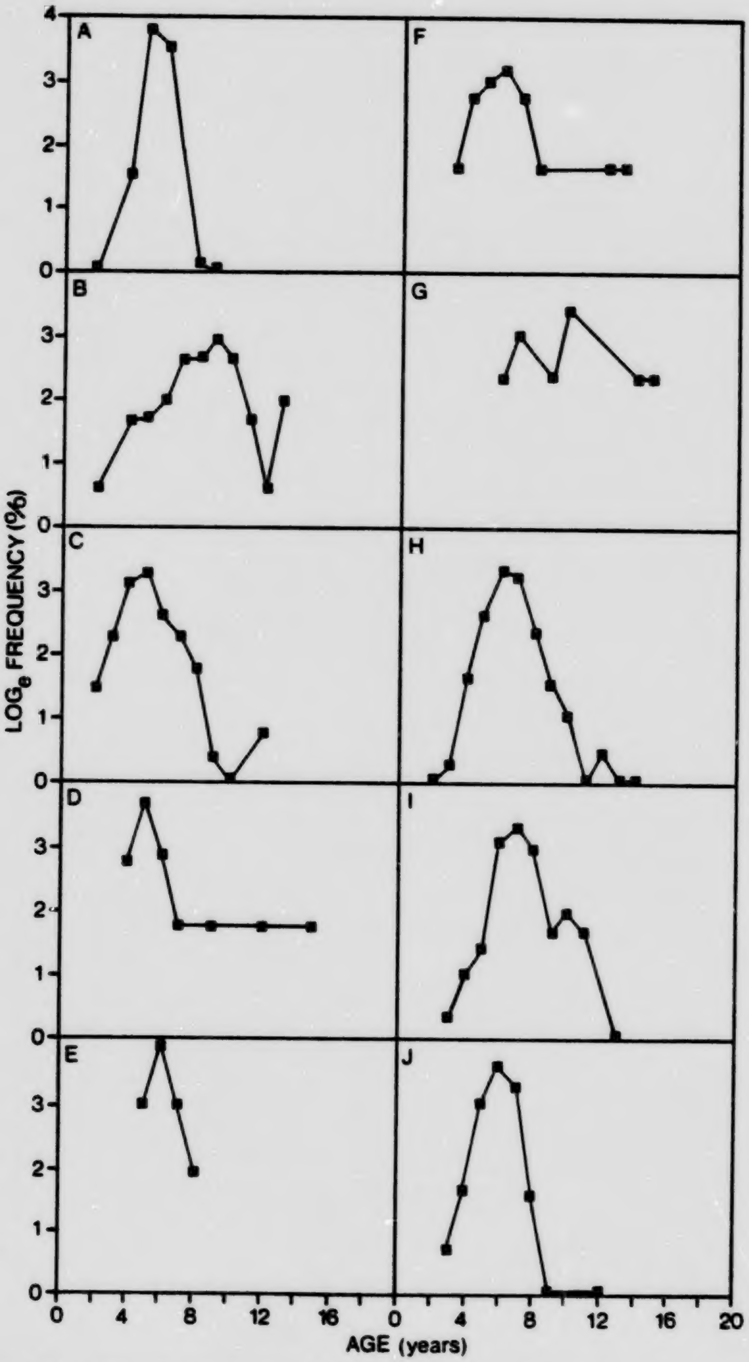

Fig. 67. Catch curves of whitefish from Semple Lake(A) and pike from Ankle(B), Bearhead(C), Pine(D), James(E), Numakoos(F), X(G), Mackerracher I(H), Mackerracher II(I) and Cuddle(J) Lakes.

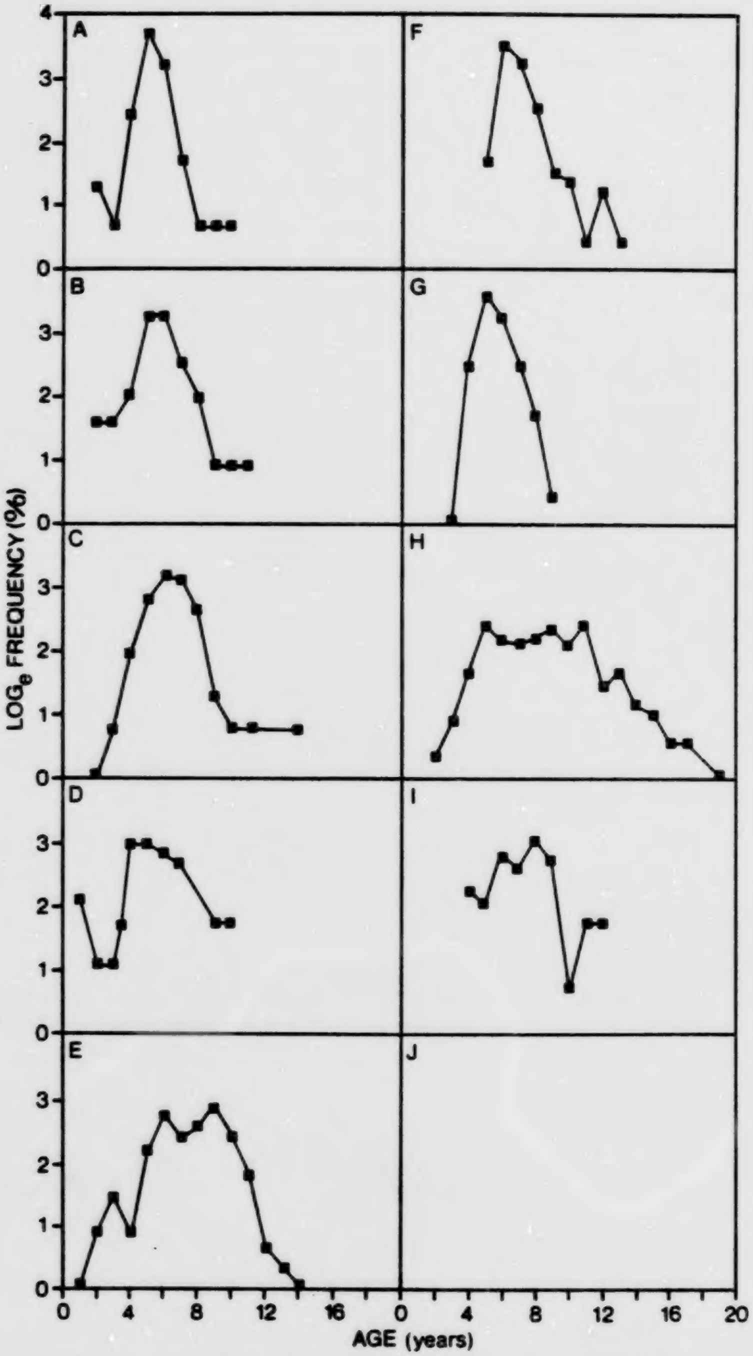

Fig. 68. Catch curves of pike from Semple(A), Wass(B), Denison(C), Willow(D), Enatik(E), Max(F), Whitefish(G), MacBride(H) and Fairy Rock(I) Lakes.

Table 22. Robson-Chapman and regression estimates of walleye, pike and whitefish mortality rates.

Species	Lake	Robson-Chapman			Regression		
		Z	A	S ± 2 S.E.	Z	A	S
walleye	Denison	1.69	.8155	.1153< .1831< .4814	1.849	.8428	.1572
	Willow	1.28	.7220	.0188< .2789< .5390	1.513	.7791	.2209
	Enatik	1.39	.2491	-.2290 .2502< .7294	1.587	.7961	.2039
	Max	0.92	.6015	.1690< .3989< .6288	0.829	.5640	.4360
	Fairy Rock	0.61	.4566	.3308< .5425< .7542	0.506	.3995	.6005
	Semple	1.16	.5918	.0193< .3125< .6057	0.215	.1975	.8025
	Cuddle	1.87	.4523	.0339< .1538< .3416	0.677	.4934	.5066
	Wass	1.48	.7724	.0762< .2283< .5328	1.365	.7459	.2541
	Mackerracher I	0.91	.5975	.1523< .4000< .6476	0.752	.5276	.4724
	MackerracherII	1.47	.7701	-.0555< .2305< .5165	1.040	.6465	.3535
	X	0.81	.5551	.2657< .4444< .6230	0.896	.5934	.4066
	Bearhead	1.95	.8577	-.1717< .1424< .4566	0.579	.4401	.5599
	Ankle	0.88	.6651	.0251< .4167< .8083	0.602	.4512	.5488
	Aswapiswanan	0.97	.6209	.0306< .3784< .7261	0.668	.4883	.5117
pike	Denison	0.69	.4984	.2791< .5001< .7212	0.514	.3995	.6005
	Willow	0.61	.7486	.2999< .5416< .7832	0.132	.1219	.8781
	Enatik	0.76	.5323	.1403< .4678< .7954	0.588	.4457	.5543
	Max	0.51	.3995	.3348< .5979< .8610	0.359	.3023	.6977
	Whitefish	0.92	.6015	.1663< .3976< .6289	1.048	.6501	.3499
	MacBride	0.38	.3161	.4302< .6838< .9373	0.365	.3093	.6907
	Fairy Rock	0.56	.4288	.3064< .5713< .8363	0.185	.1730	.8270
	Semple	1.48	.7724	.2272< .4098< .5924	0.623	.4621	.5379
	Cuddle	1.51	.7791	-.0363< .2195< .4754	0.586	.4457	.5543
	Wass	0.66	.4831	.2962< .5152< .7341	0.512	.3995	.6005
	Mackerracher I	0.77	.5370	.2490< .4646< .6801	0.541	.4173	.5827

Whitefish	Mackerracher II	0.95	.6133	-.0498	<.3866	<.8230	0.564	.4288	.5712
	Bearhead	0.72	.5132	.2189	<.4875	<.7561	0.418	.3430	.6570
	Ankle	0.61	.4566	.2469	<.5417	<.8366	0.318	.3430	.7261
	Numakoos	0.64	.4727	.3171	<.5293	<.7415	0.805	.5551	.4449
	James	1.16	.6865	.1316	<.3126	<.4935	1.039	.6465	.3535
	Pine	0.65	.4780	.3454	<.5237	<.7021	0.973	.6209	.3791
	Denison	1.39	.7509	-.0194	<.2499	<.5192	1.499	.7769	.2231
	Willow	0.52	.4055	.3736	<.5937	<.8138	0.293	.2517	.7483
	Enatik	0.67	.4883	.2621	<.5112	<.7604	0.483	.3812	.6188
	Max	0.68	.5066	.2913	<.5095	<.7272	0.551	.4230	.5769
	Whitefish	2.19	.8881	-.0855	<.1110	<.3075	1.412	.7558	.2441
	Fairy Rock	1.06	.6535	.0840	<.3477	<.6114	0.853	.5726	.4274
	Semple	1.67	.8118	-.0238	<.1887	<.4013	1.554	.7878	.2122
	Cuddle	0.44	.3560	.4672	<.6453	<.8233	0.066	.0676	.9324
	Mackerracher I	0.59	.4457	.3053	<.5531	<.8010	0.695	.5034	.4966
	Mackerracher II	0.84	.5683	.0954	<.4323	<.7693	1.176	.6927	.3073
	Bearhead	1.05	.6501	.0820	<.3478	<.6137	1.099	.6671	.3329
	Ankle	0.51	.3995	.3172	<.6000	<.8828	0.505	.3995	.6005
	Numakoos	0.38	.3161	.5502	<.6842	<.8182	0.293	.2517	.7483
	McPherson	1.32	.7329	-.0761	<.2664	<.6089	1.100	.6671	.3329
	Aswapiswanan	1.27	.7192	.0117	<.2820	<.5524	0.972	.6209	.3791

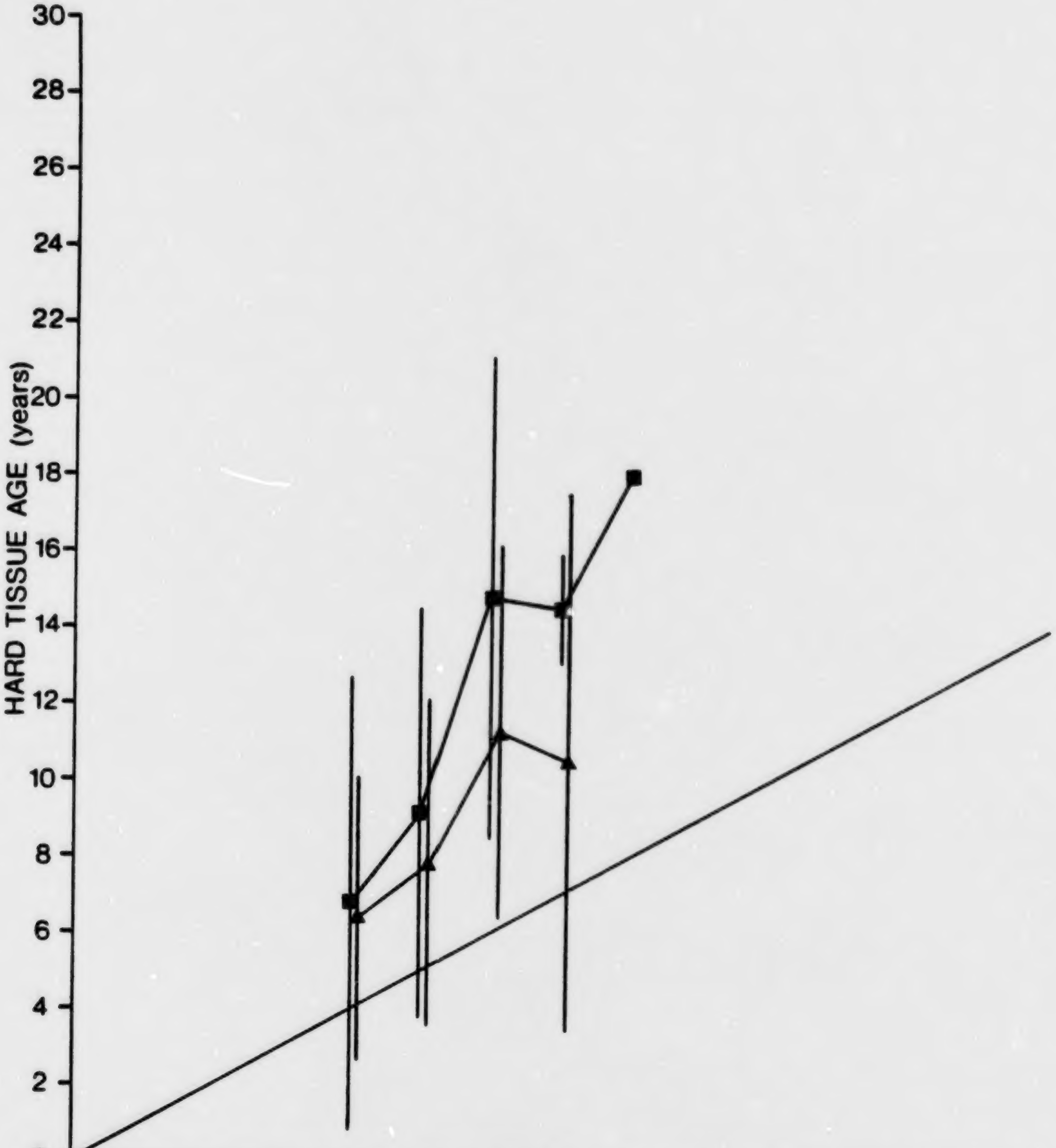

Fig. 69. Differences among scale ages, mean otolith ages (■) and mean spine ages (▲) of Semple Lake walleyes. Vertical bars are ± 2 S.D. about means. The slope of the agreement line is 1.

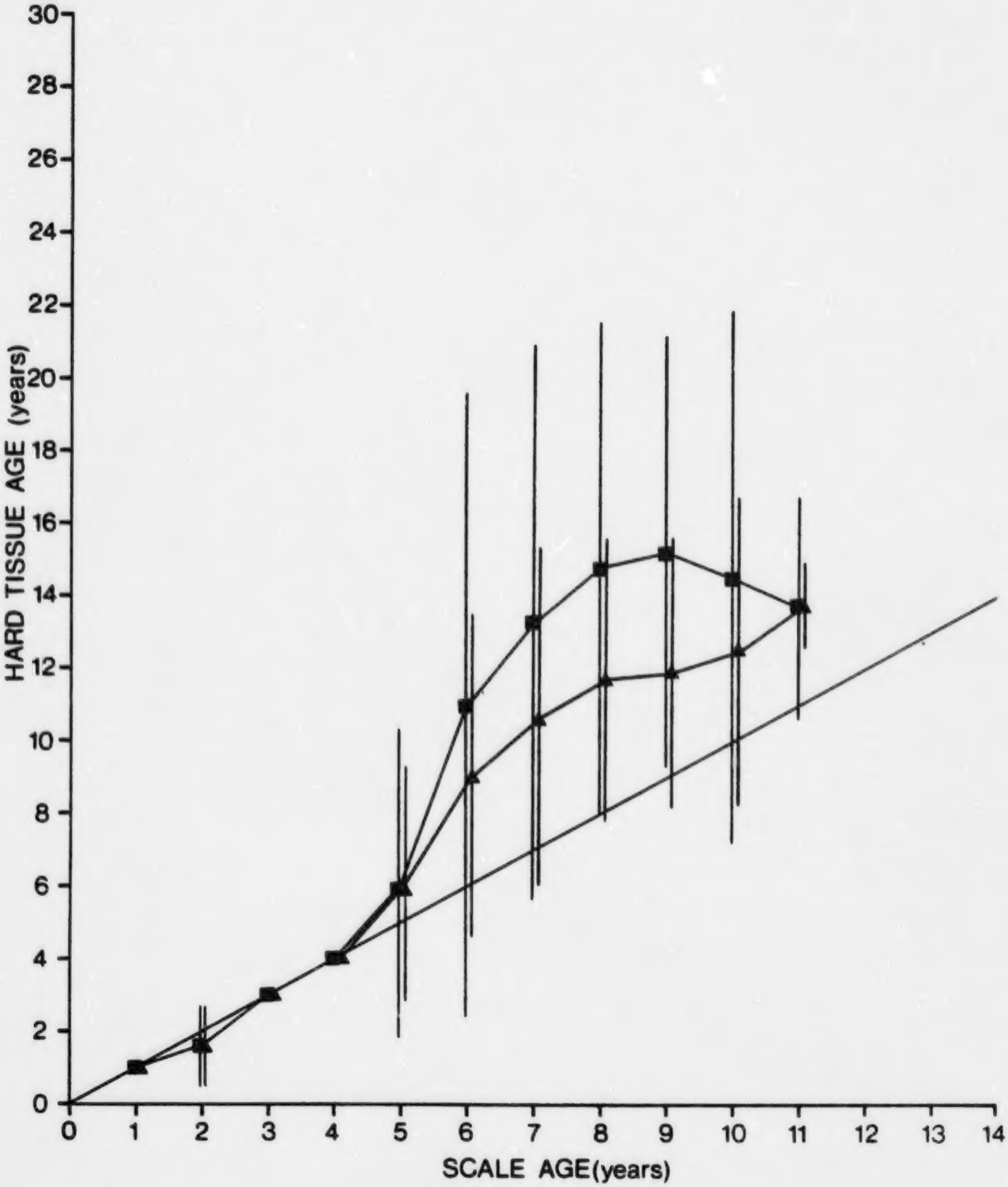

Fig. 70. Differences among scale ages, mean otolith ages (■) and mean spine ages (▲) of Wass Lake walleyes. Vertical bars are ± 2 S.D. about means. The slope of the agreement line is 1.

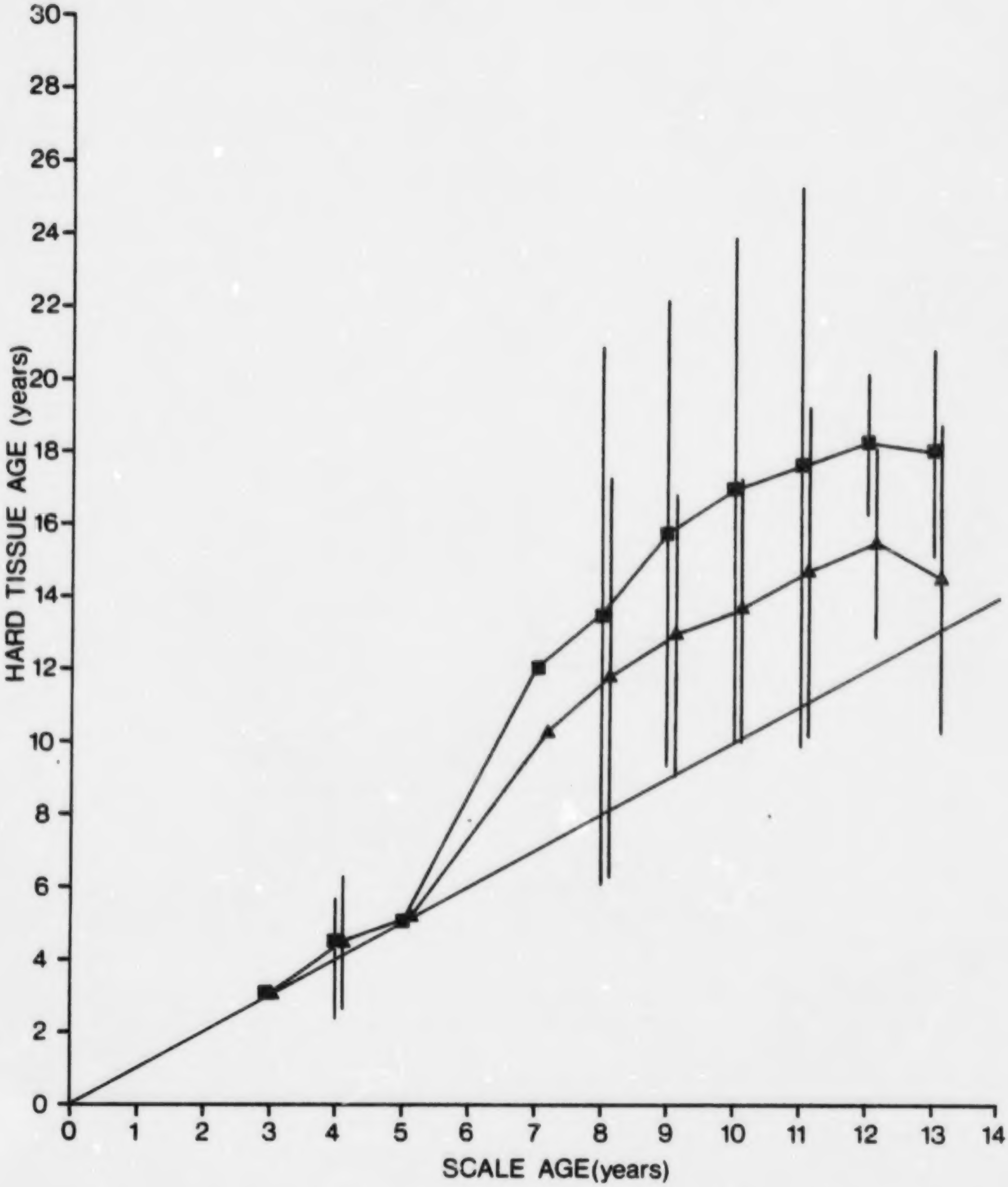

Fig. 71. Differences among scale ages, mean otolith ages (■) and mean spine ages (▲) of Ankle Lake walleyes. Vertical bars are ± 2 S.D. about means. The slope of the agreement line is 1.

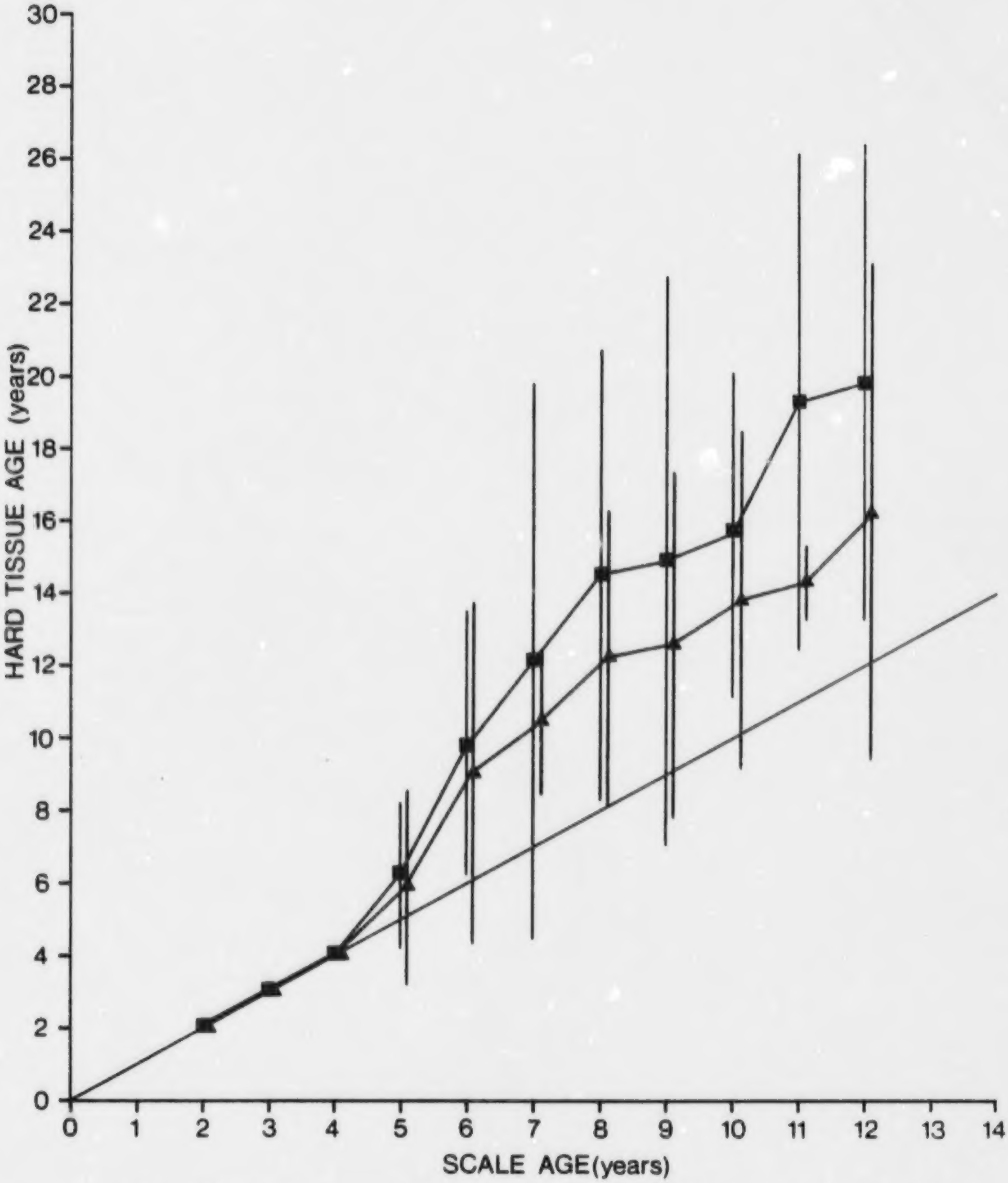

Fig. 72. Differences among scale ages, mean otolith ages (■) and mean spine ages (▲) of Aswapiswanan Lake walleyes. Vertical bars are ± 2 S.D. about means. The slope of the agreement line is 1.

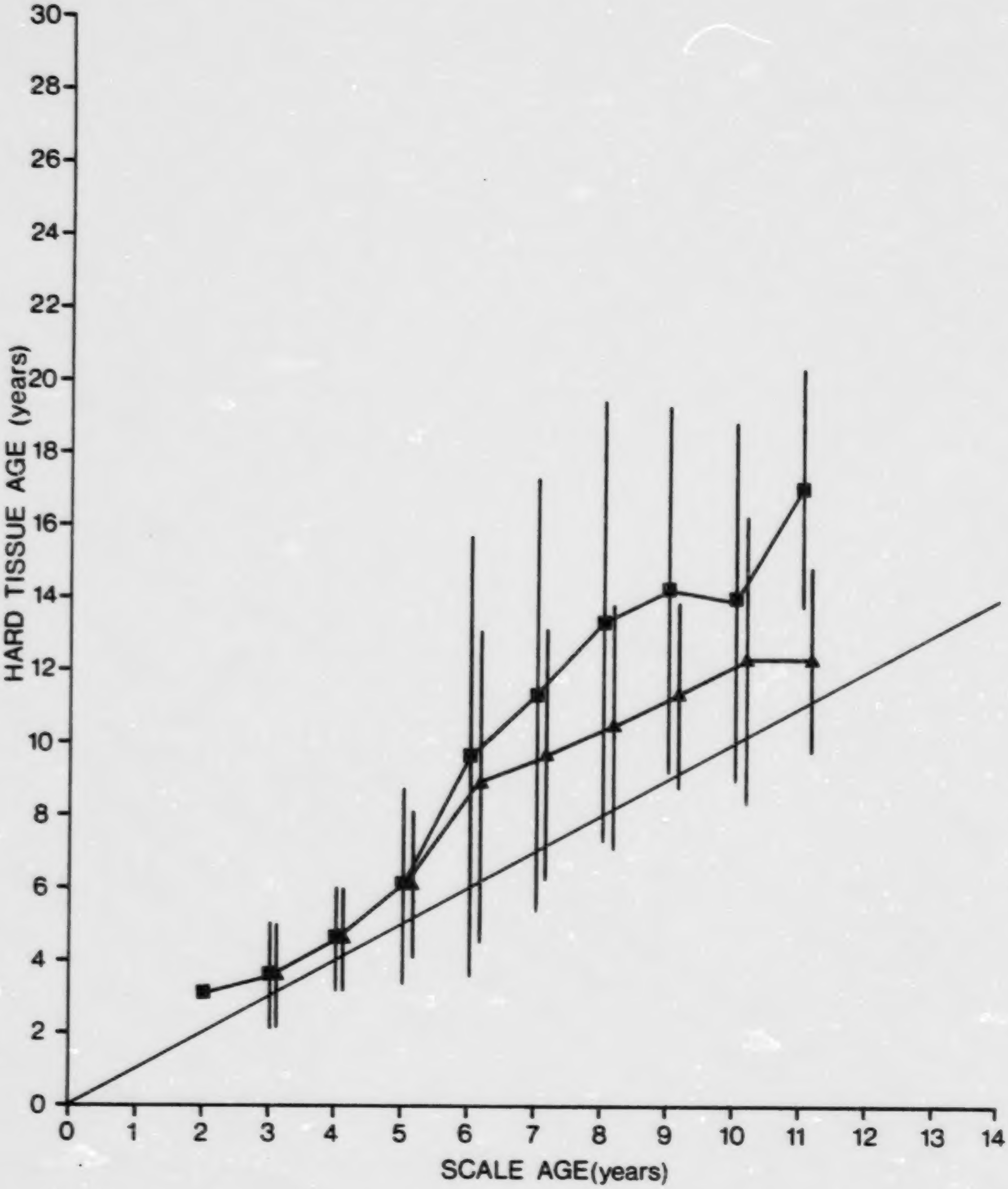

Fig. 73. Differences among scale ages, mean otolith ages (■) and mean spine ages (▲) of Willow Lake walleyes. Vertical bars are ± 2 S.D. about means. The slope of the agreement line is 1.

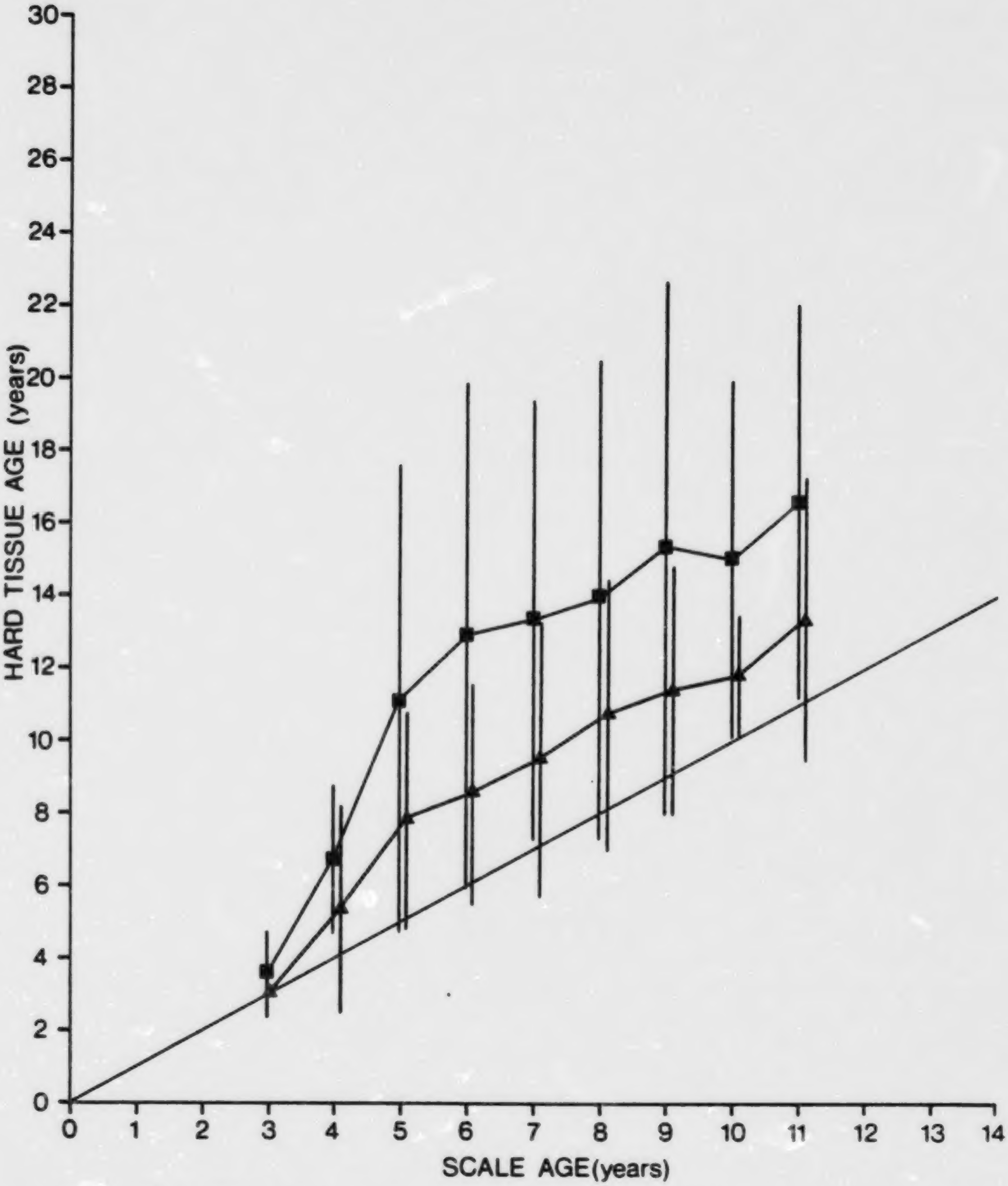

Fig. 74. Differences among scale ages, mean otolith ages (■) and mean spine ages (▲) of Fairy Rock Lake walleyes. Vertical bars are ± 2 S.D. about means. The slope of the agreement line is 1.

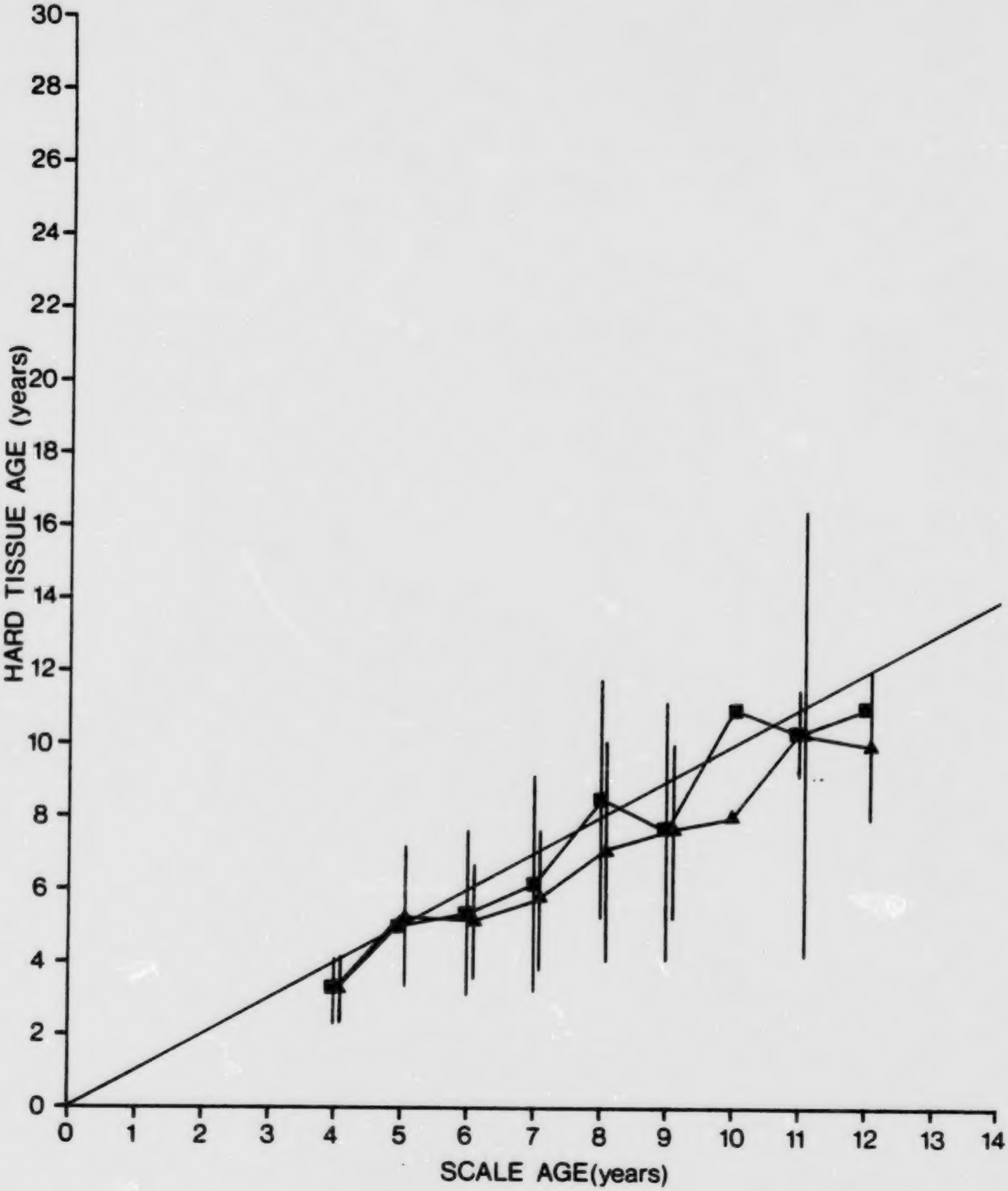

Fig. 75. Differences among scale ages, mean opercular ages (■) and mean fin ray ages of Fairy Rock Lake pike. Vertical bars are ± 2 S.D. about means. The slope of the agreement line is 1.

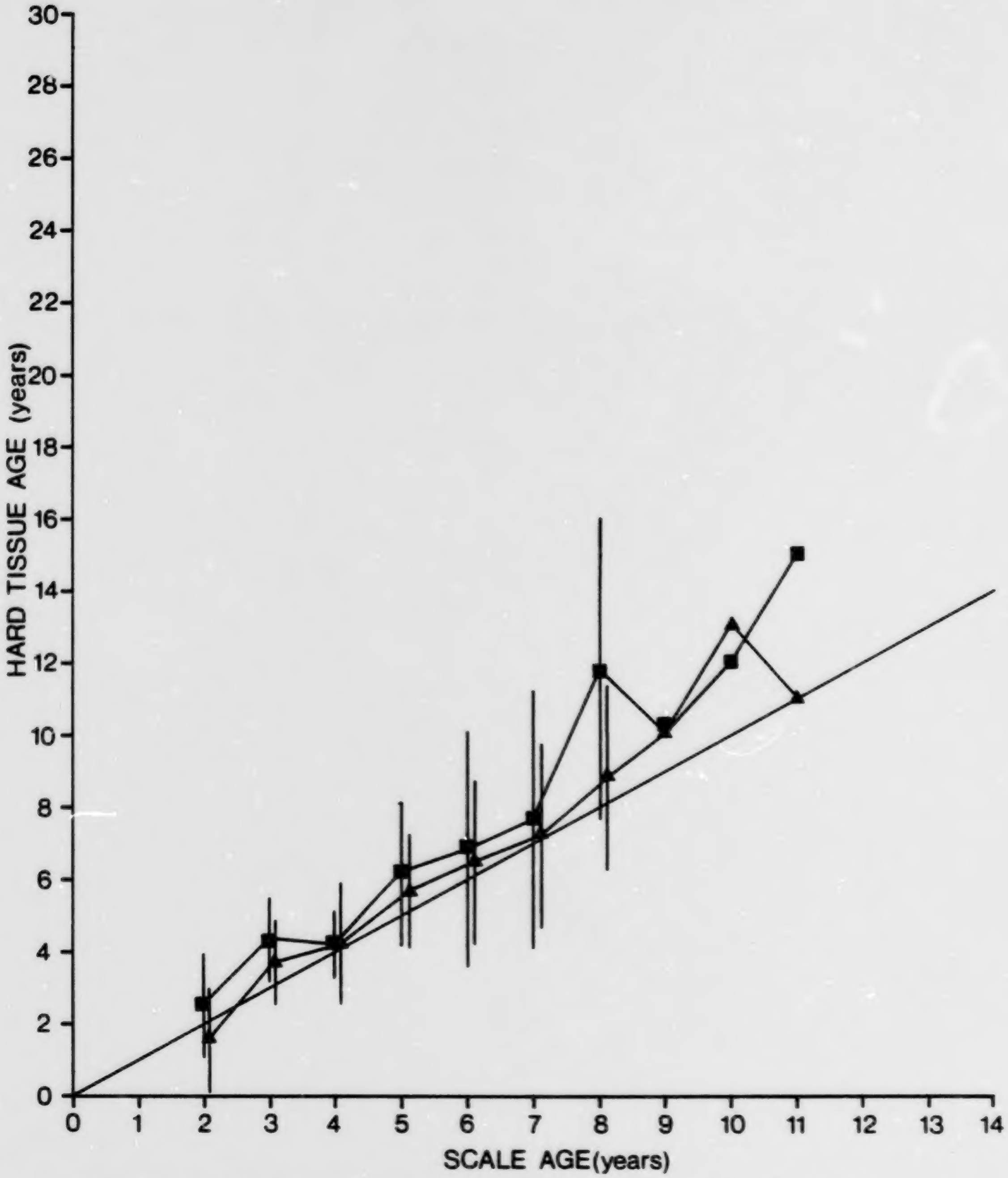

Fig. 76. Differences among scale ages, mean opercular ages (■) and mean fin ray ages (▲) of Wass Lake pike. Vertical bars are ± 2 S.D. about means. The slope of the agreement line is 1.

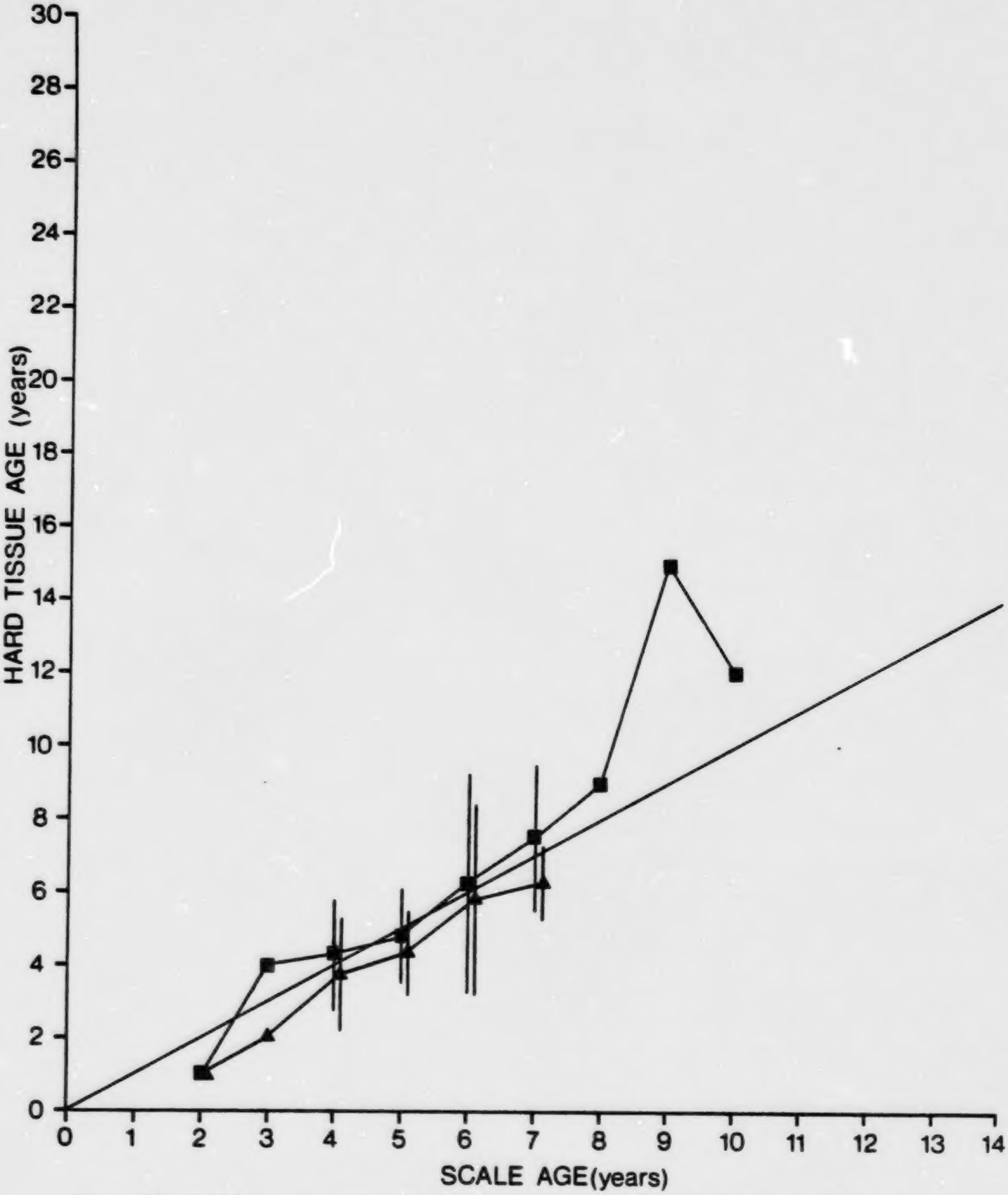

Fig. 77. Differences among scale ages, mean opercular ages (■) and mean fin ray ages (▲) of Semple Lake pike. Vertical bars are ± 2 S.D. about means. The slope of the agreement line is 1.

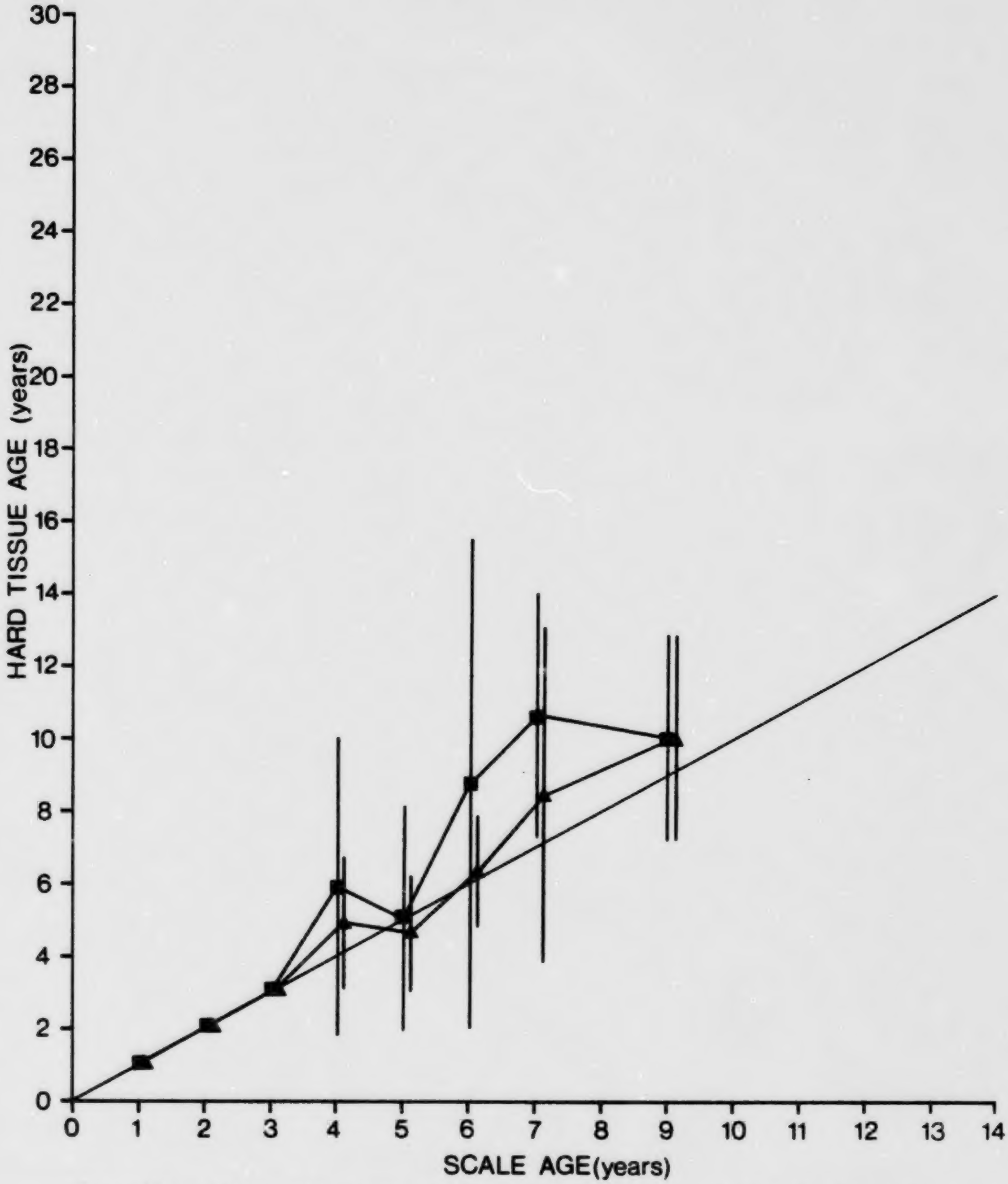

Fig. 78. Differences among scale ages, mean opercular ages (■) and mean fin ray ages (▲) of Willow Lake pike. Vertical bars are ± 2 S.D. about means. The slope of the agreement line is 1.

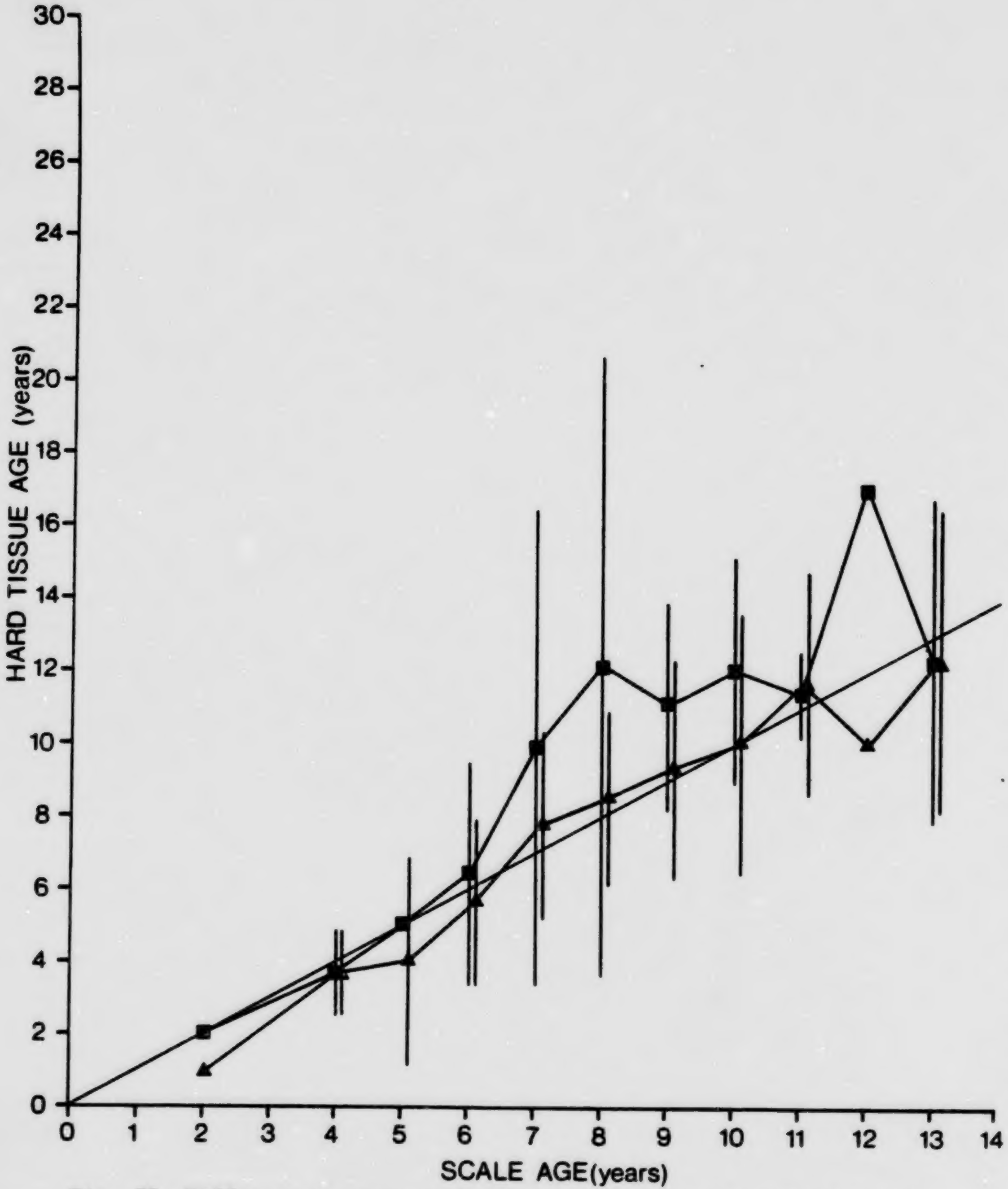

Fig. 79. Differences among scale ages, mean opercular ages (■) and mean fin ray ages (▲) of Ankle Lake pike. Vertical bars are ± 2 S.D. about means. The slope of the agreement line is 1.

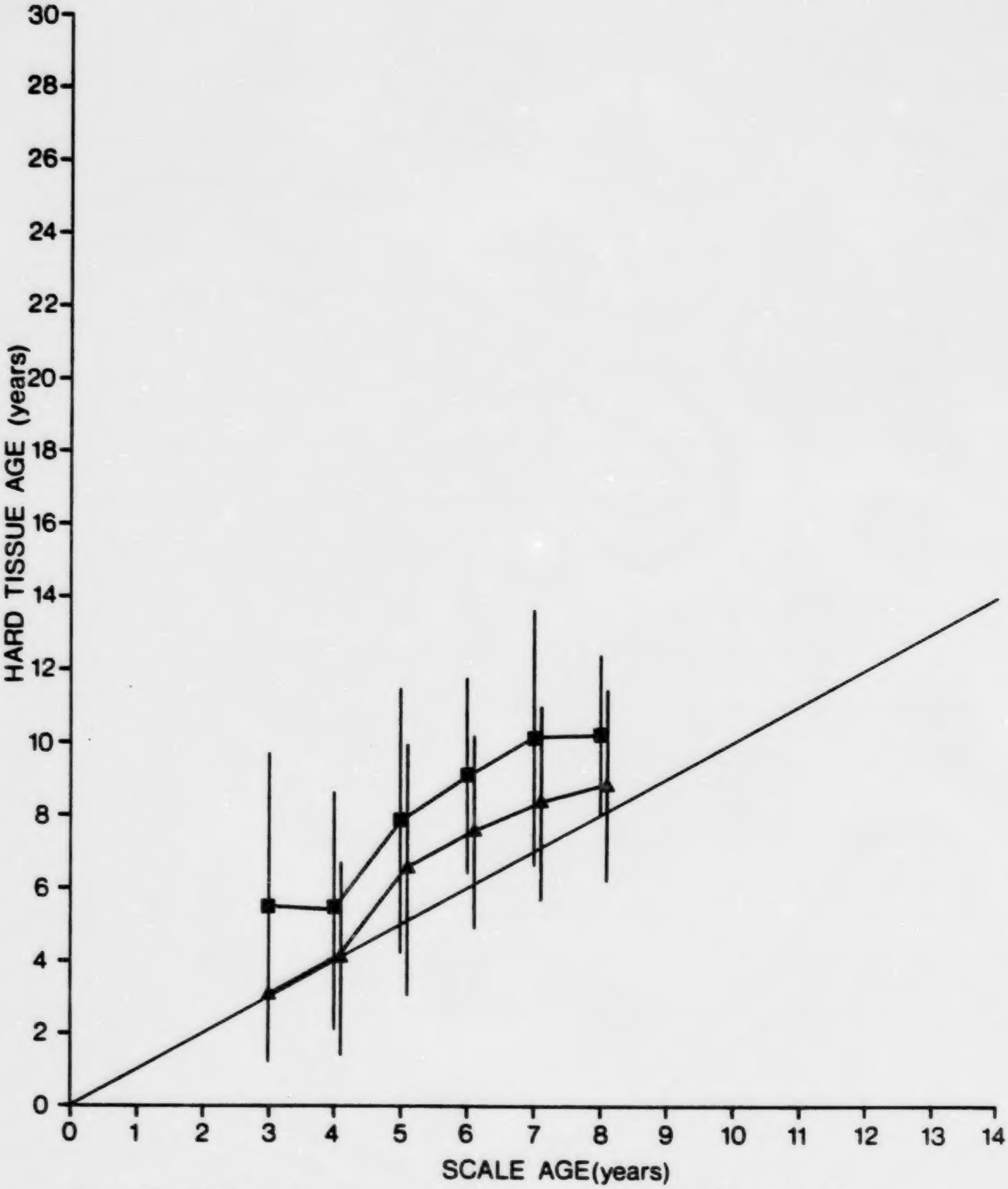

Fig. 80. Differences among scale ages, mean opercular ages(■), and mean fin ray ages(▲) of Whitefish Lake pike. Vertical bars are ± 2 S.D. about means. The slope of the agreement line is 1.

Plots comparing whitefish scale ages to their respective mean otolith and fin ray ages generally shared the same characteristics as those of the walleye age comparisons. However, discrepancies among whitefish scale ages and their corresponding mean otolith and fin ray ages were generally less than those of walleyes (Figs. 81-85).

Commercial sampling

Table 23 summarizes regression analyses of round versus dressed weights of commercially important species. Column a predicts dressed weight given round weight. Column b predicts round weight given dressed weight. High correlation coefficients indicate a good linear fit for all species. Pike displayed the greatest mean difference between round and dressed weights and the greatest standard deviation of this difference in all surveyed lakes (Table 23).

Denison Lake

Group 3 caught the most fish while group 2 caught the least amount (Table 24). Daily catches of all species by groups 1-3 decreased irregularly with time (Figs. 86-88). Combined daily catches of walleyes and pike caught by all groups of fishermen decreased regularly with time (Figs. 89,90) while daily catches of whitefish decreased irregularly with time (Fig. 91). Daily catches of whitefish decreased rapidly while daily catches of walleyes and pike declined slowly (Table 25). Daily catches of all fish by all groups of fishermen (Fig. 92) decreased 38.5 lbs. per day (Table 25).

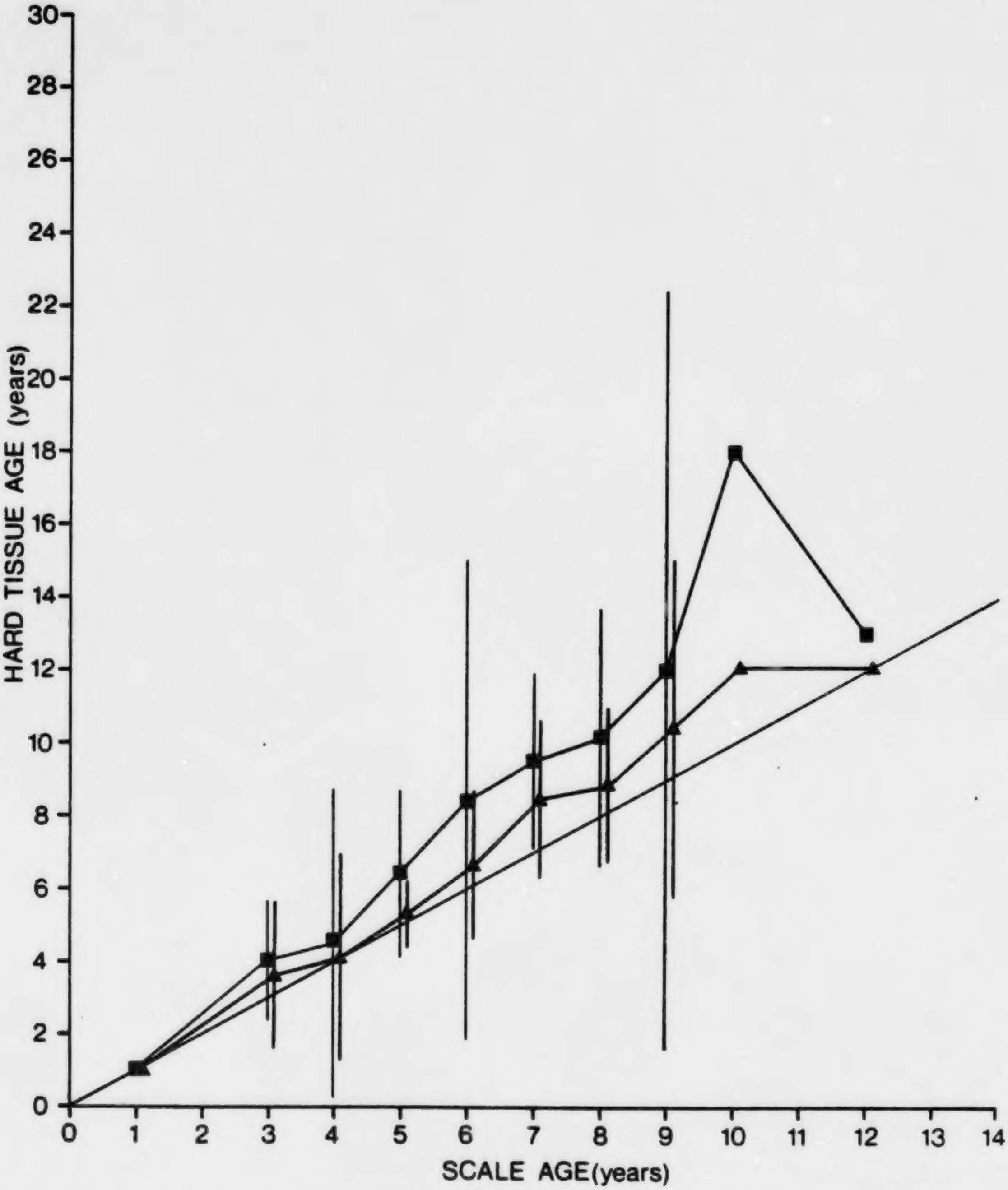

Fig. 81. Differences among scale ages, mean otolith ages (■), and mean fin ray ages (▲) of Fairy Rock Lake whitefish. Vertical bars are ± 2 S.D. about means. The slope of the agreement line is 1.

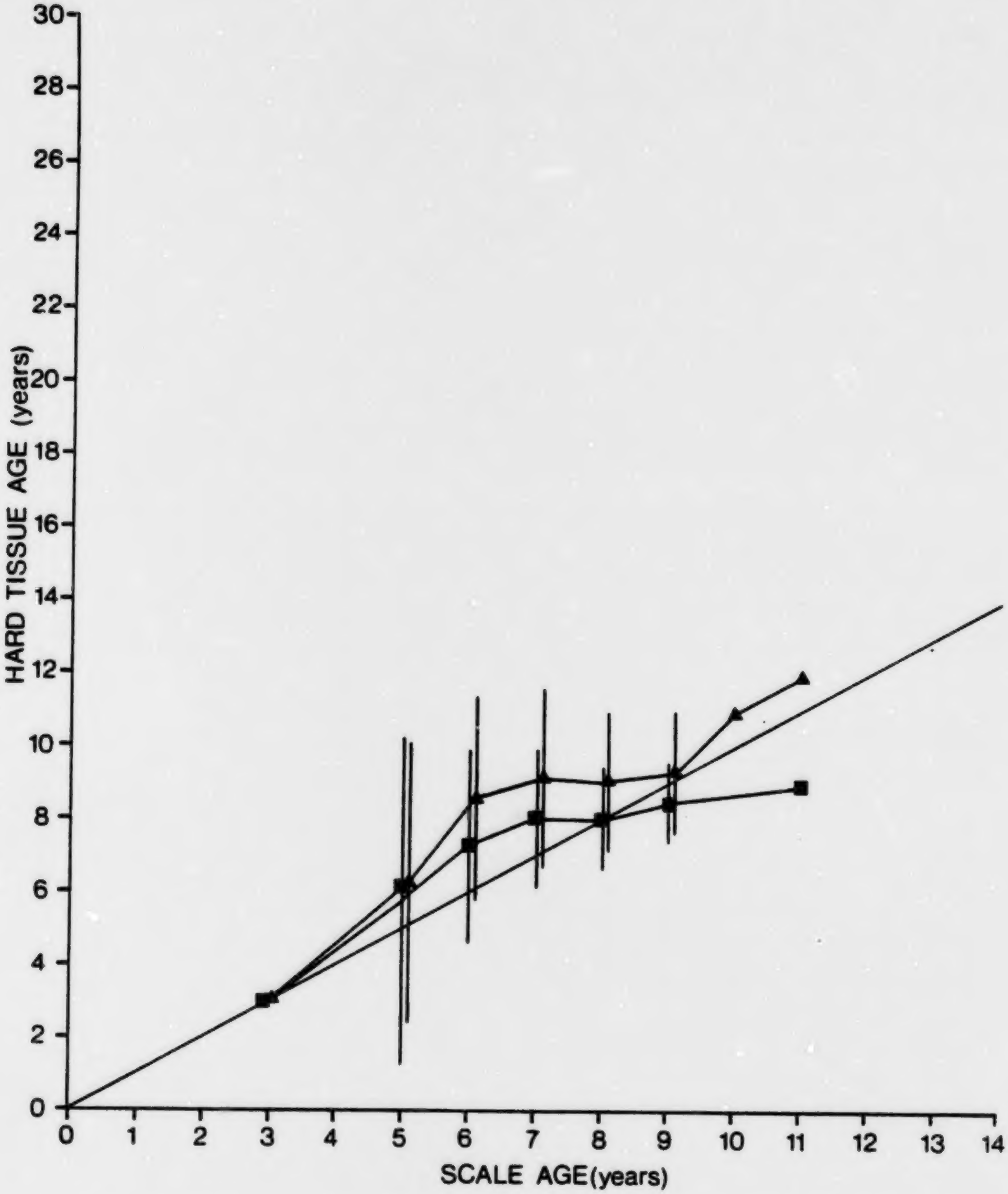

Fig. 82. Differences among scale ages, mean fin ray ages (■) and mean otolith ages (▲) of Whitefish Lake whitefish. Vertical bars are ± 2 S.D. about means. The slope of the agreement line is 1.

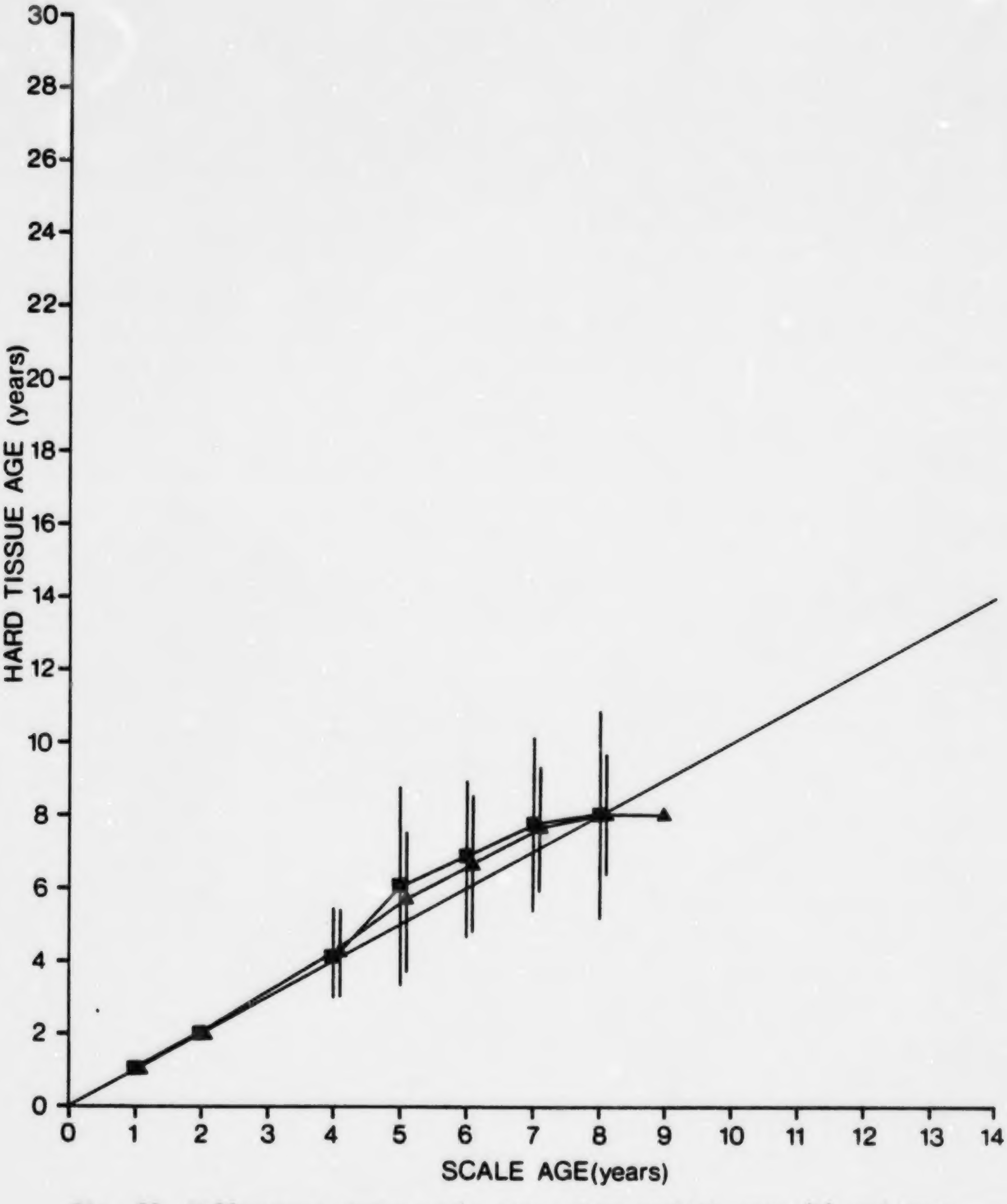

Fig. 83. Differences among scale ages, mean otolith ages (■) and mean fin ray ages (▲) of Semple Lake whitefish. Vertical bars are ± 2 S.D. about means. The slope of the agreement line is 1.

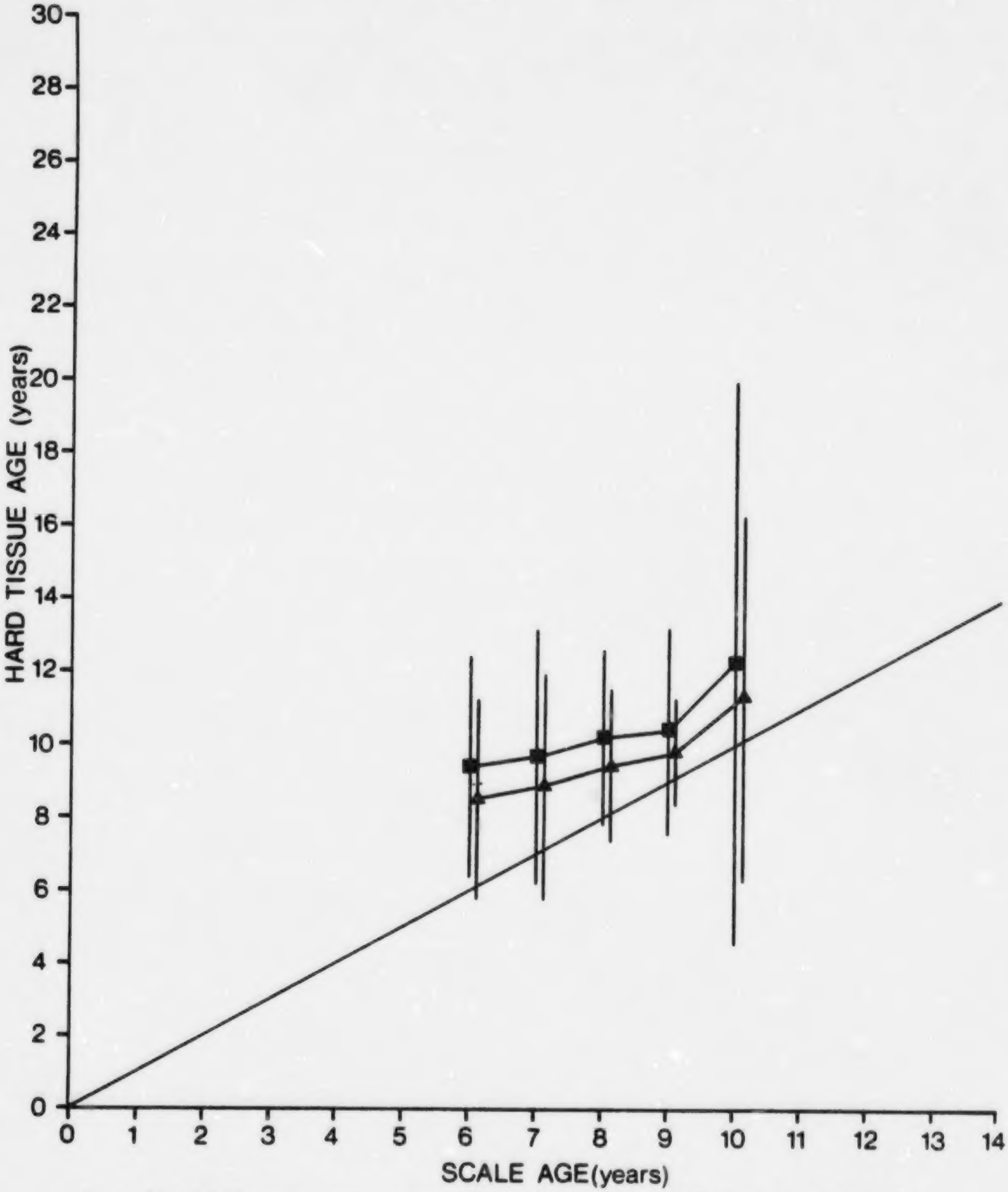

Fig. 84. Differences among scale ages, mean otolith ages (■) and mean fin ray ages (▲) of Aswapiswanan Lake whitefish. Vertical bars are ± 2 S.D. about means. The slope of the agreement line is 1.

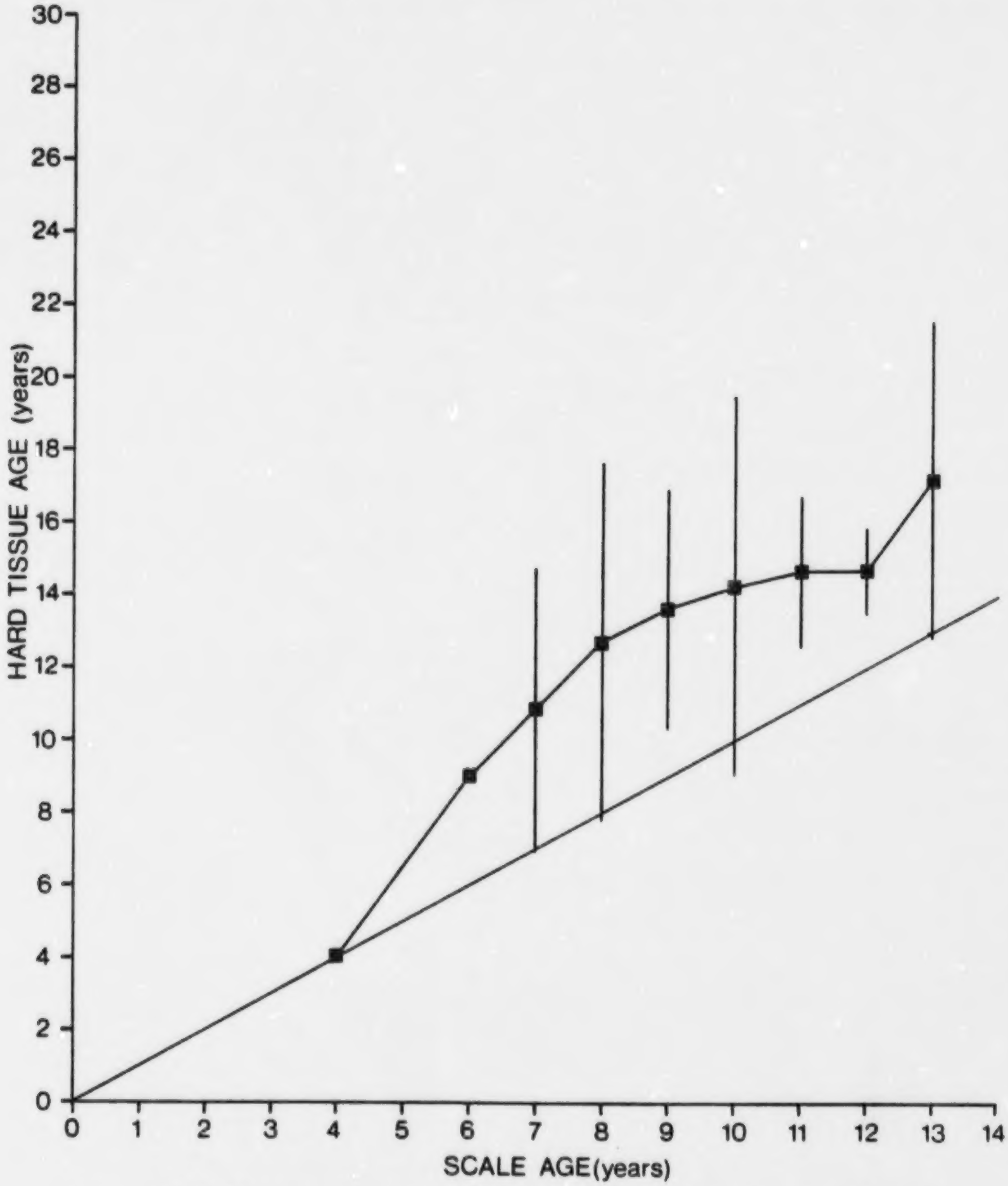

Fig. 85. Differences among scale ages and mean fin ray ages of Ankle Lake whitefish. Vertical bars are ± 2 S.D. about means. The slope of the agreement line is 1.

Table 23. Regression analyses of round and dressed weights of commercially caught fish.

Lake and species	$\overline{X}$ = mean round wt. (kg.)	$\overline{Y}$ = mean dressed wt. (kg.)	$\overline{D} = \overline{X}-\overline{Y}$	S.D.$_{\overline{X}}$	S.D.$_{\overline{Y}}$	S.D.$_{\overline{D}}$	R	a. Linear equation Y = a + bX	b. Linear equation X = a + bY	Test F value
Denison										
whitefish	0.969	0.817	0.152	0.165	0.121	0.059	0.961	Y = 0.134 + 0.704X	X = 0.102 + 1.311Y	278.9* (1,23 d.f.)
walleye	0.867	0.585	0.282	0.197	0.129	0.073	0.986	Y = 0.023 + 0.648X	X =−0.012 + 1.503Y	834.51* (1,23 d.f.)
pike	1.644	1.060	0.583	0.925	0.578	0.361	0.991	Y = 0.043 + 0.619X	X =−0.039 + 1.587Y	1246.58* (1,22 d.f.)
Mackerracher										
walleye	1.010	0.692	0.318	0.142	0.099	0.054	0.963	Y = 0.014 + 0.671X	X = 0.055 + 1.380Y	290.91* (1,23 d.f.)
MacBride										
whitefish	2.118	1.848	0.270	0.656	0.585	0.097	0.994	Y =−0.031 + 0.887X	X = 0.059 + 1.114Y	2268.18* (1,26 d.f.)
walleye	1.079	0.743	0.336	0.255	0.175	0.082	0.995	Y = 0.005 + 0.684X	X = 0.003 + 1.448Y	889.06* (1, 9 d.f.)
pike	2.551	1.713	0.838	1.609	1.025	0.650	0.975	Y = 0.128 + 0.621X	X = 0.072 + 1.532Y	470.0* (1,24 d.f.)

* significant

Table 24. Daily catches (lbs. dressed wt.) of three groups of fishermen on Denison Lake.

Date	Group no.														
	1					2					3				
	no. gangs	walleye	whitefish	pike	total	no. gangs	walleye	whitefish	pike	total	no. gangs	walleye	whitefish	pike	total
July 24	12	72	378	80	530	15	105	423	120	648	15	84	316	18	418
25	12	135	390	31	556	15	67	254	158	479	15	54	360	90	504
26	12	141	317	25	483	15	25	230	69	324	15	41	214	85	340
27	15	202	656	62	920	15	37	209	95	341	15	47	205	67	319
28	15	129	304	62	495	15	32	260	60	352	15	41	397	43	481
29	15	170	238	63	471	15	44	509	68	621	15	75	470	53	598
30	15	124	562	0	686	15	57	265	123	445	15	53	359	91	503
31	15	118	513	17	648	15	20	347	0	367	15	28	750	79	857
1	15	100	443	0	543	15	50	268	21	339	15	23	403	41	467
2	15	103	75	0	178	15	17	212	0	229	15	17	598	11	626
3	15	35	75	0	110	15	30	273	14	317	15	23	403	41	467
4	15	68	45	22	135	15	44	237	23	304	15	25	282	60	367
5	15	52	50	9	111	15	49	197	35	281	15	21	274	50	345
6	15	48	122	42	212	15	40	152	38	230	15	20	157	63	240
7	15	55	168	17	240	15	58	293	39	390	15	26	710	17	753
8	15	43	265	45	353	15	25	226	47	298	15	9	535	40	584
9	15	36	470	46	552	15	52	352	34	438	15	18	584	15	617
10	15	32	300	34	366	15	40	263	44	347	15	9	435	0	444
11			no fishing due to bad weather												
12	15	86	201	27	314	15	47	209	25	281	15	11	263	6	280
13	15	51	157	46	254	15	15	218	22	255	15	17	611	39	667
14	15	16	131	9	156	15	44	192	0	236	15	0	345	0	345
15	15	-	97	13	110	15	28	163	33	224	15	9	591	0	600

16	15	17	141	36	194	15	-	156	7	163	15	0	265	16	281
17	15	25	36	32	93	15	16	130	30	176	15	6	266	19	291
18	15	23	36	25	84	15	13	226	17	256	15	0	243	3	246
19	15	25	164	22	211	15	6	303	25	334	15	4	185	11	200
20	15	16	90	18	124	15	0	28	11	39	15	0	70	5	75
21	—	—	—	—	—	15	8	271	20	229	15	0	119	4	123
	396	1922	6424	783	9129	420	969	6866	1178	9013	420	661	10410	967	12038[t]

---

[t] total weight of all fish = 30180 lbs.

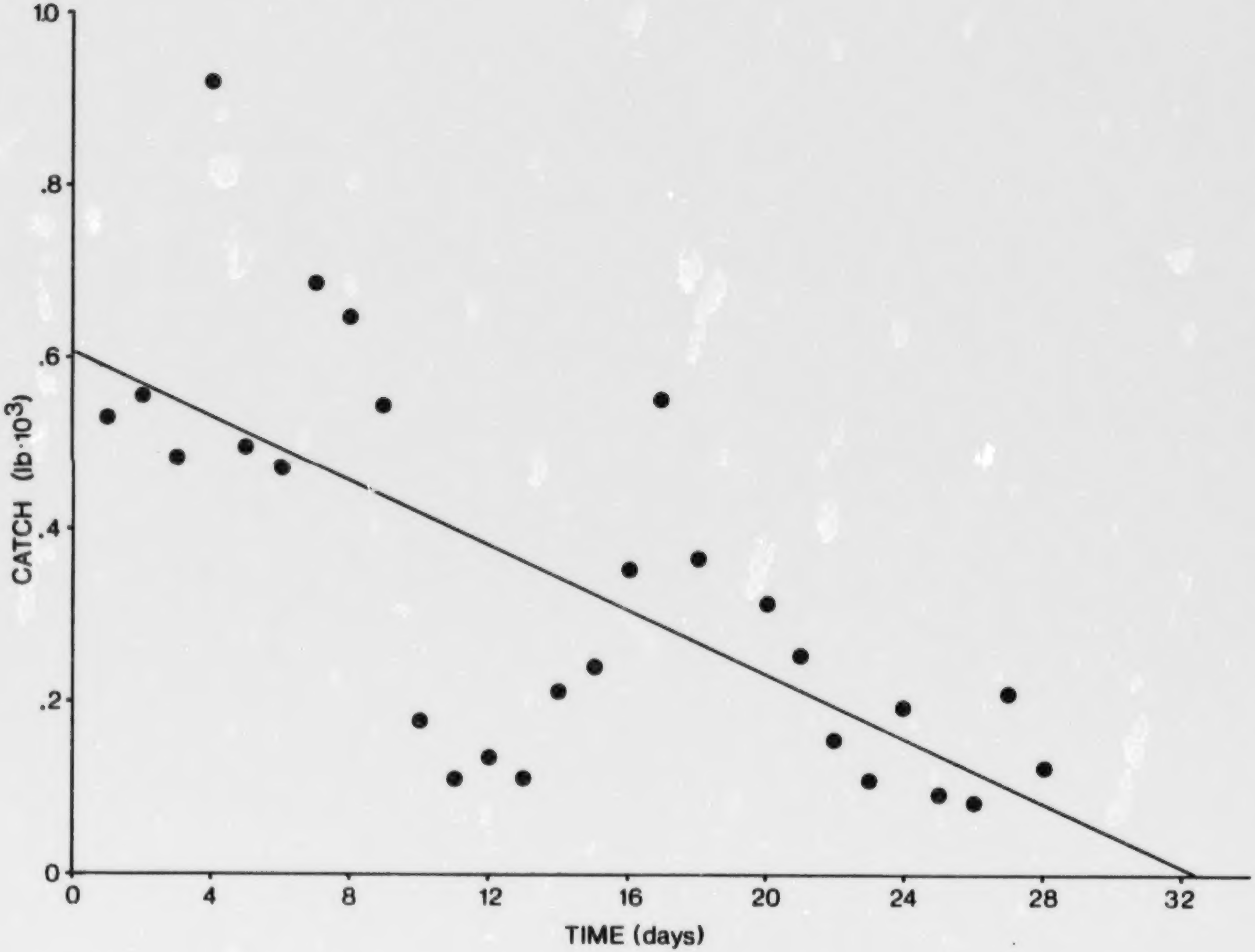

Fig. 86. Daily catches of all species by group 1 from Denison Lake.

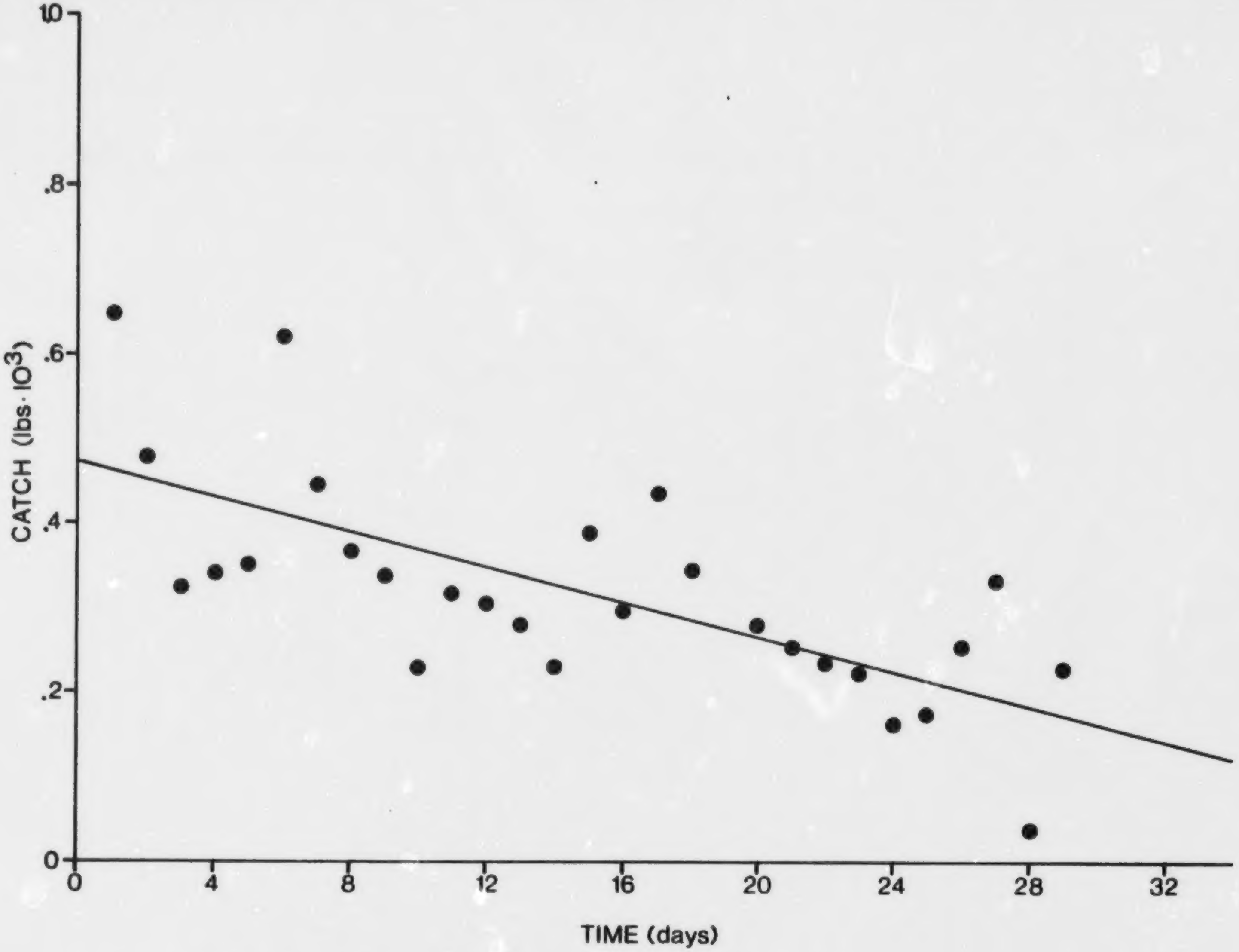

Fig. 87. Daily catches of all species by group 2 from Denison Lake.

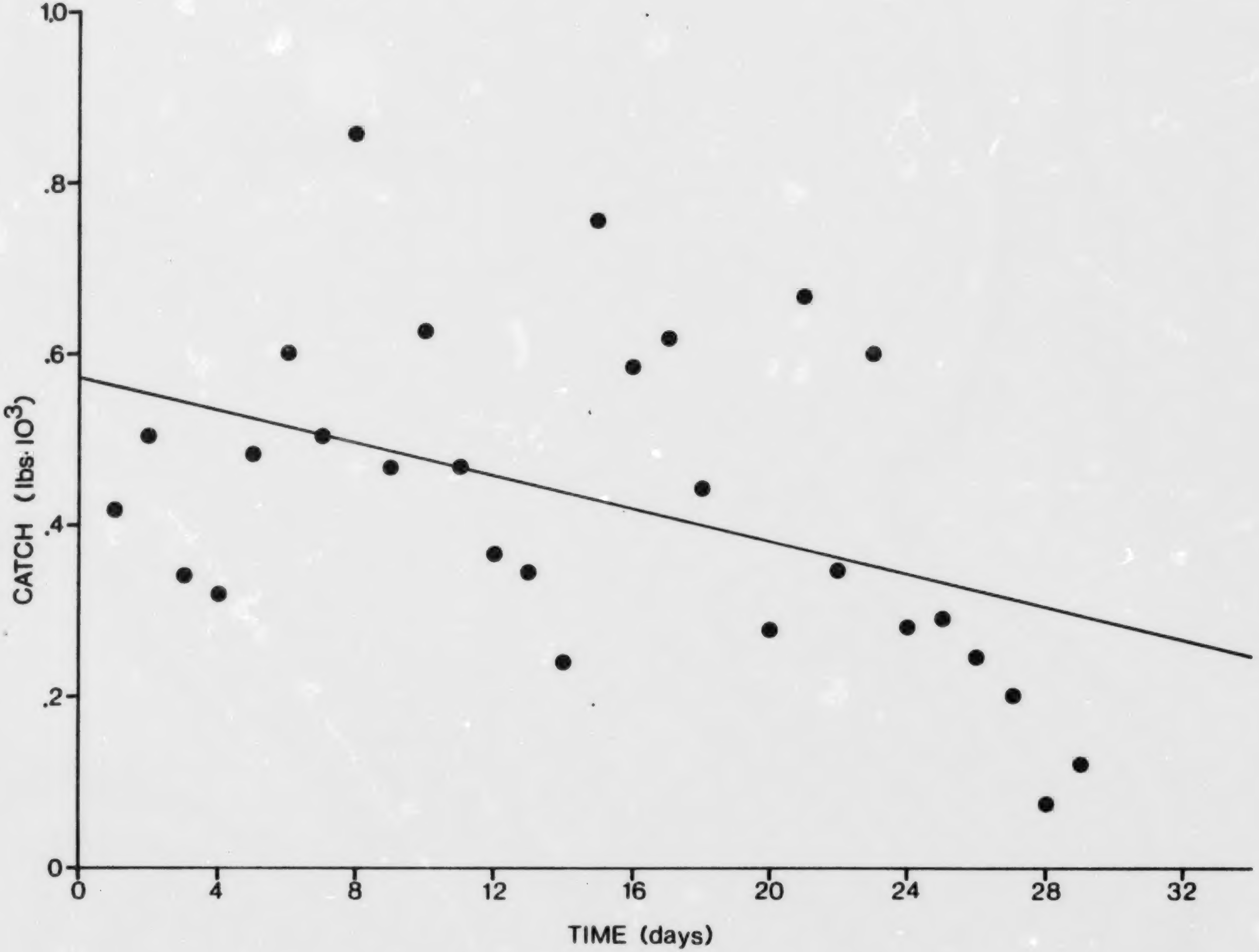

Fig. 88. Daily catches of all species by group 3 from Denison Lake.

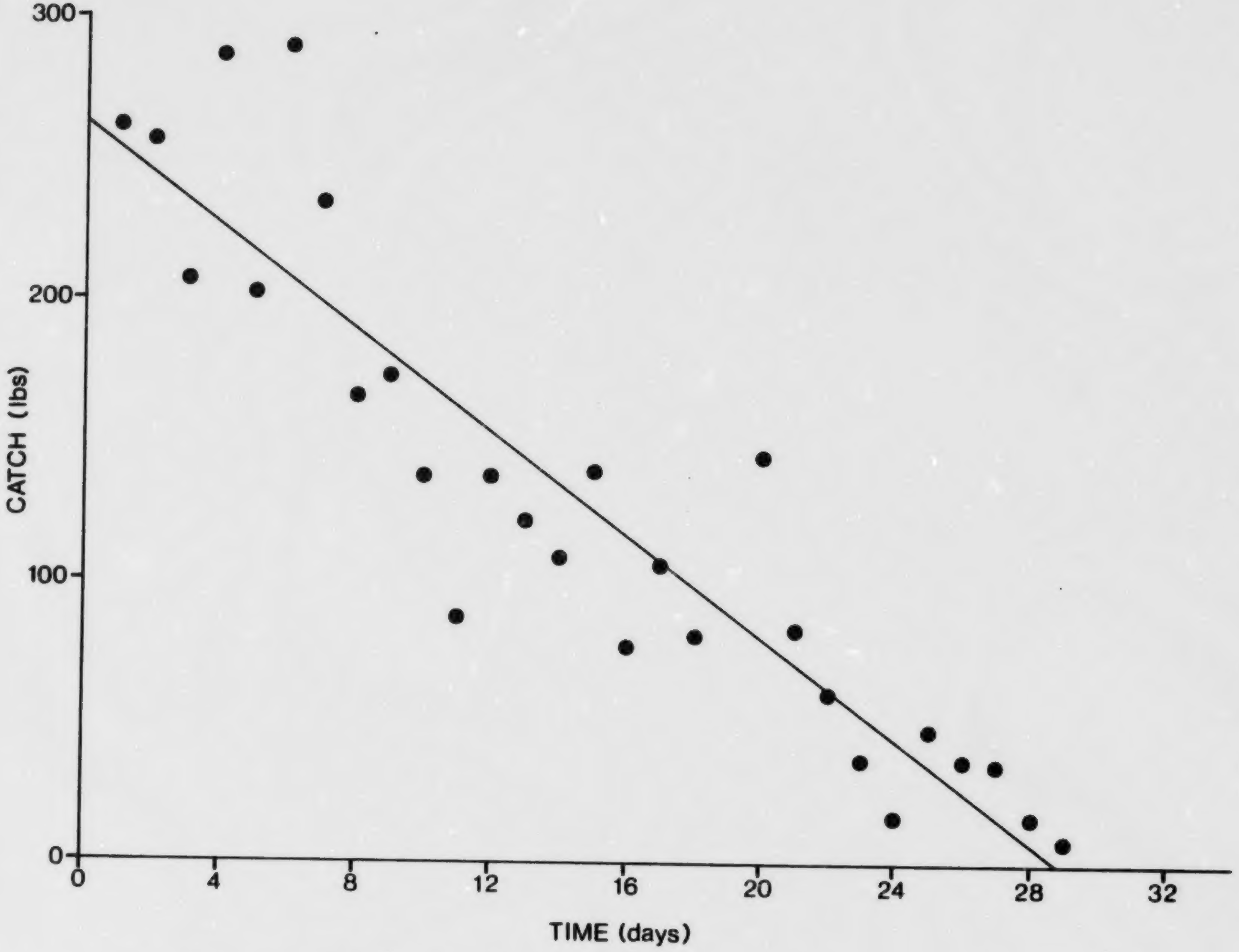

Fig. 89. Total daily catches of walleyes from Denison Lake.

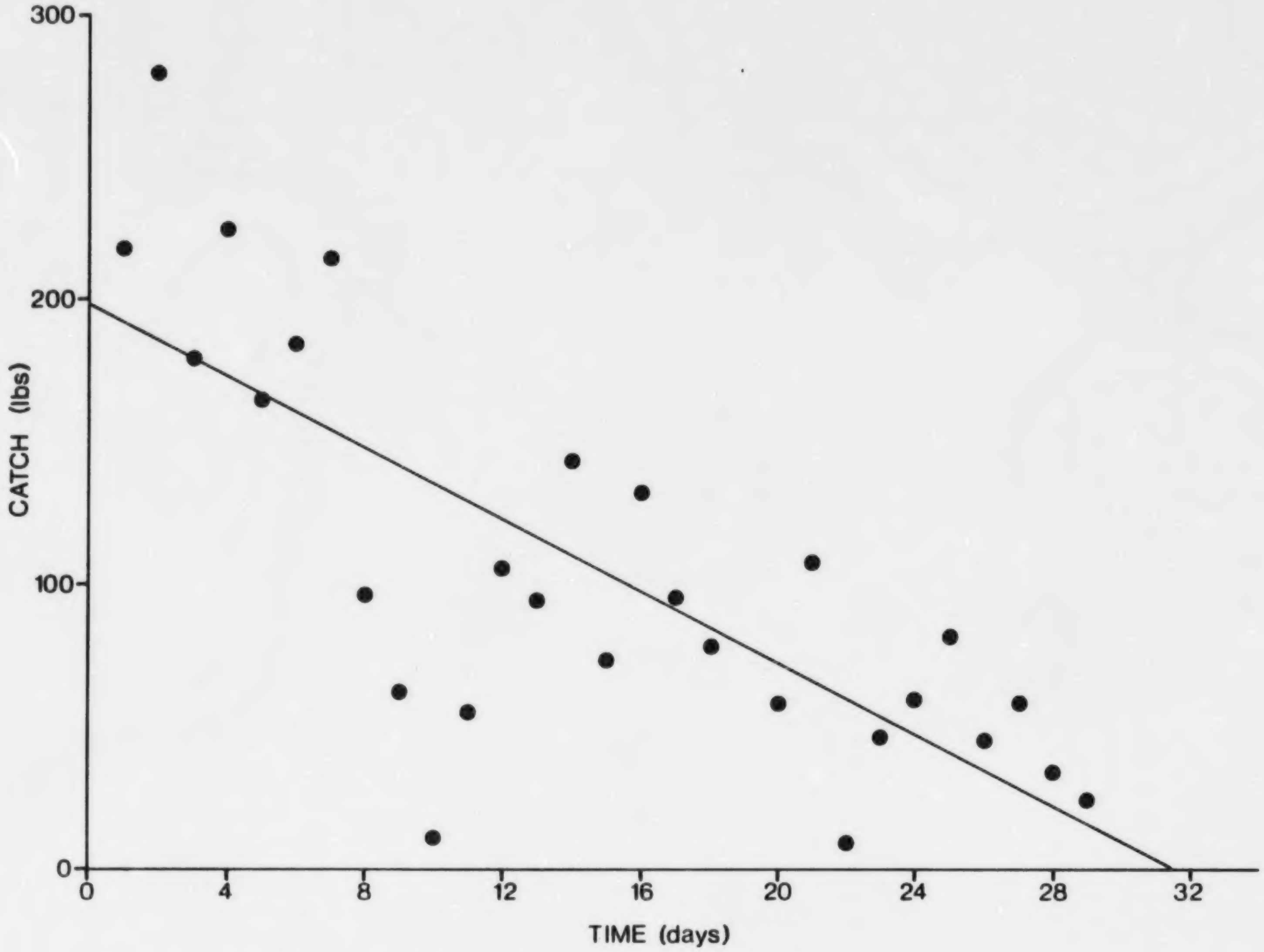

Fig. 90. Total daily catches of pike from Denison Lake.

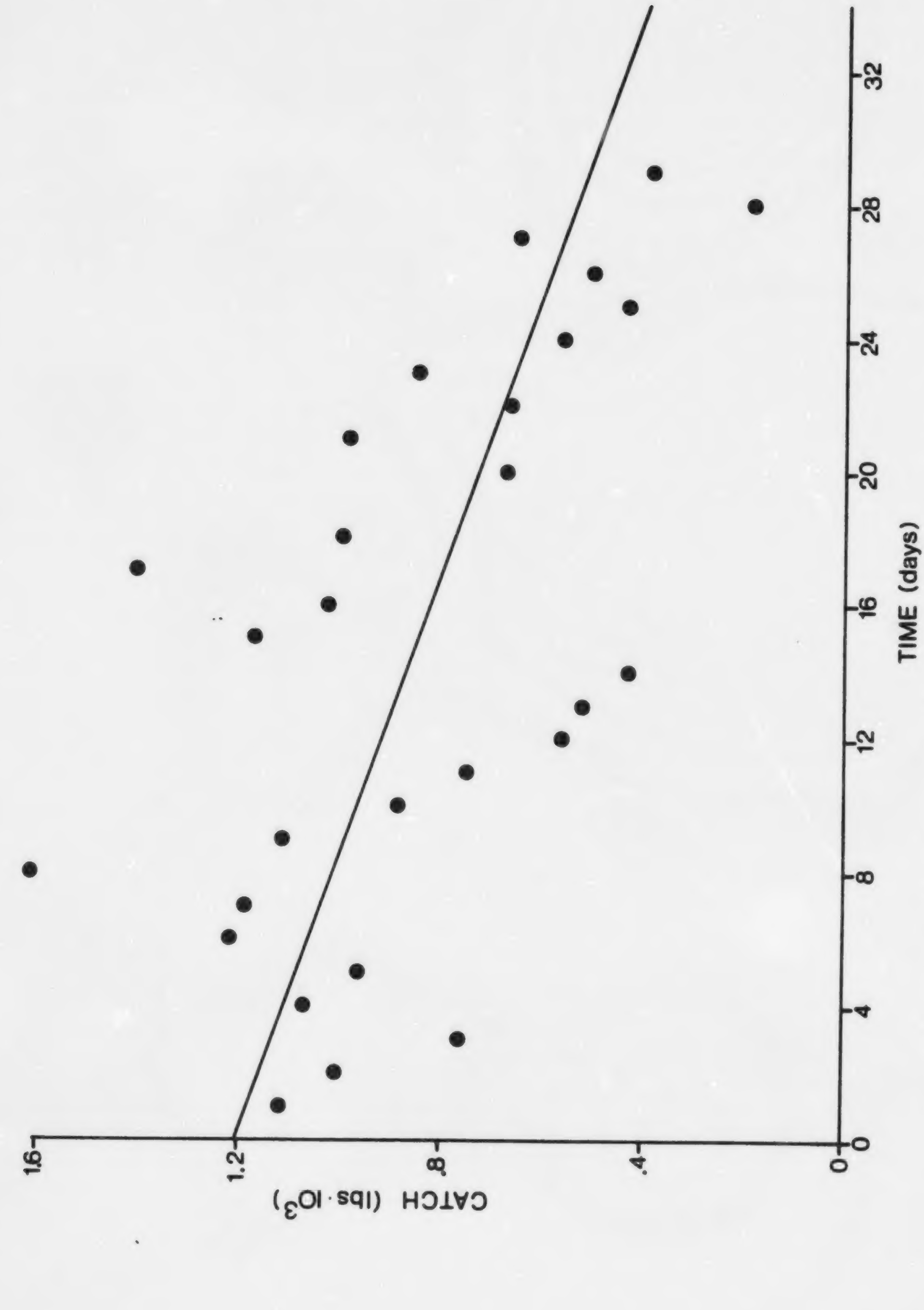

Fig. 91. Total daily catches of whitefish from Denison Lake.

Table 25. Regressions of daily catches of Denison Lake fishermen.

Species	Linear equation	R	S.D. y	X-intercept (days)	Test F value (1 and 26 d.f., P = 0.05)
walleye	Y = 262.429 - 9.125X	-0.922	85.44	28	148.10
whitefish	Y =1189.902 -23.118X	-0.594	336.02	51	14.18
pike	Y = 197.744 - 6.271X	-0.761	71.19	31	35.72
Total	Y =1650.075 -38.515X	-0.764	435.17	42	36.52

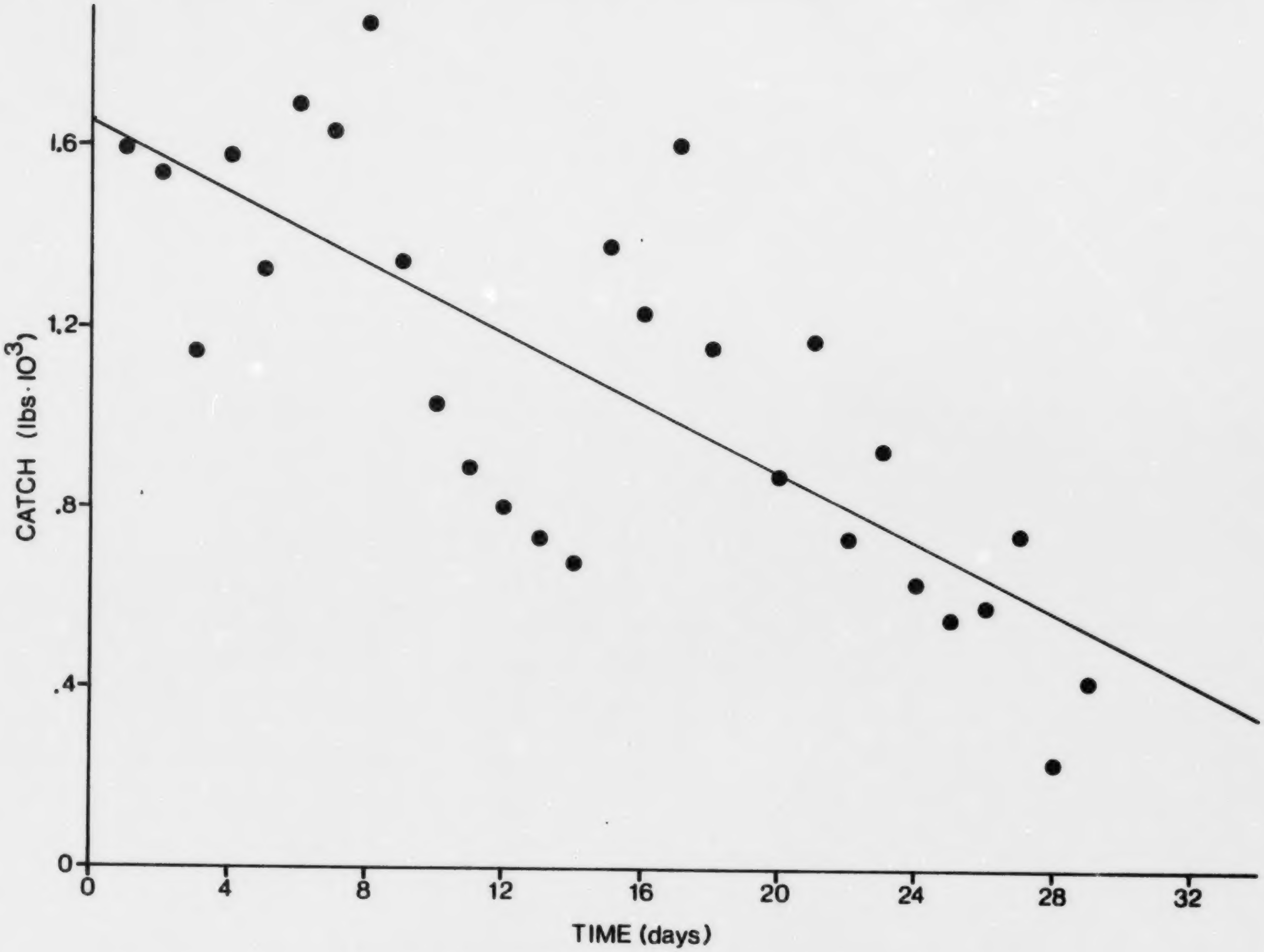

Fig. 92. Daily catches of all species by all groups of fishermen from Denison Lake.

Mackerracher I and II Lakes

Table 26 lists daily catches of walleyes, pike and whitefish caught by all three groups of fishermen on the Mackerracher Lakes. Daily catches of individual groups were not recorded. (Fishing effort was assumed to be equal among all groups). Daily catches of walleyes and pike declined more reguarly than catches of whitefish (Figs. 93-98). On Mackerracher I Lake, catches of walleyes and pike decreased by 9.7 and 10.3 lbs. day^{-1}, respectively (Table 27). The x-intercepts of these curves are 9-12 days longer than the actual fishing period. Conversely, the whitefish catches decreased irregularly at a slower rate (7.7 lbs. day^{-1}) and the predicted fishing period was twice as long as the actual fishing period (Table 27). Daily catches of all species declined 27.6 lbs. day^{-1} and the intercept (53 days) was twice as long as the actual fishing period (Fig. 99). Fishing effort was irregular. The mean number of gangs set daily in Mackerracher I Lake was 29.5, i.e., each group set less than 10 gangs day^{-1}.

Daily catches of walleyes and pike in Mackerracher II Lake decreased slower than in Mackerracher I Lake, resulting in longer predicted fishing periods (Table 27). Daily catches of whitefish in Mackerracher II Lake did not change significantly with time (Table 27). The predicted fishing period for Mackerracher II Lake was more than three times the actual fishing period (Fig. 100). As in Mackerracher I, fishing effort was low (mean of 26 gangs day $^{-1}$) and irregular.

Table 26. Daily catches (lbs. dressed weight) from the Mackerracher Lakes.

Date	no. gangs	walleye	whitefish	pike	total
Mackerracher I					
June 7	30	448	789	274	1511
8	30	476	417	505	1398
9	30	358	604	453	1415
10	30	312	296	512	1120
11	20	181	340	354	875
26	24	250	712	152	1114
27	34	260	746	68	1074
28	36	102	915	121	1138
29	36	74	901	84	1059
30	36	132	582	82	796
July 1	36	51	492	249	792
2	36	92	526	188	806
3	36	21	156	38	215
4	36	61	600	134	795
5	36	21	452	130	603
6	36	29	645	118	792
7	36	53	529	90	672
8	36	7	680	144	831
9	36	60	639	120	819
10	36	28	593	66	687
11	36	62	566	64	692
12	36	64	605	84	753
13	20	20	344	3	367
14	30	18	401	68	487
15	20	0	124	6	130
16	8	8	43	8	59
17	20	3	114	0	117
18	7	5	23	16	44
19	6	6	85	4	95
totals	849	3202	13919	4135	21256
Mackerracher II					
June11	10	479	494	52	1025
12	30	247	390	652	1289
13	30	372	559	528	1459
14	30	346	676	336	1358
15	30	272	773	221	1266
16	30	218	430	185	833
17	30	194	594	346	1134
18	30	?	?	?	-
19	30	349	387	625	1361
20	30	248	403	530	1181
21	30	188	383	152	723
22	30	146	571	248	965
23	30	135	651	253	1039
24	32	113	457	230	800
25	32	58	375	85	518

July13	10	13	217	24	254
14	6	0	47	9	56
15	16	0	156	21	177
16	21	12	353	82	447
17	16	15	435	0	450
18	29	24	1023	59	1106
19	30	20	1146	57	1223
20	36	19	814	57	890
totals	598	3468	11334	4752	19554

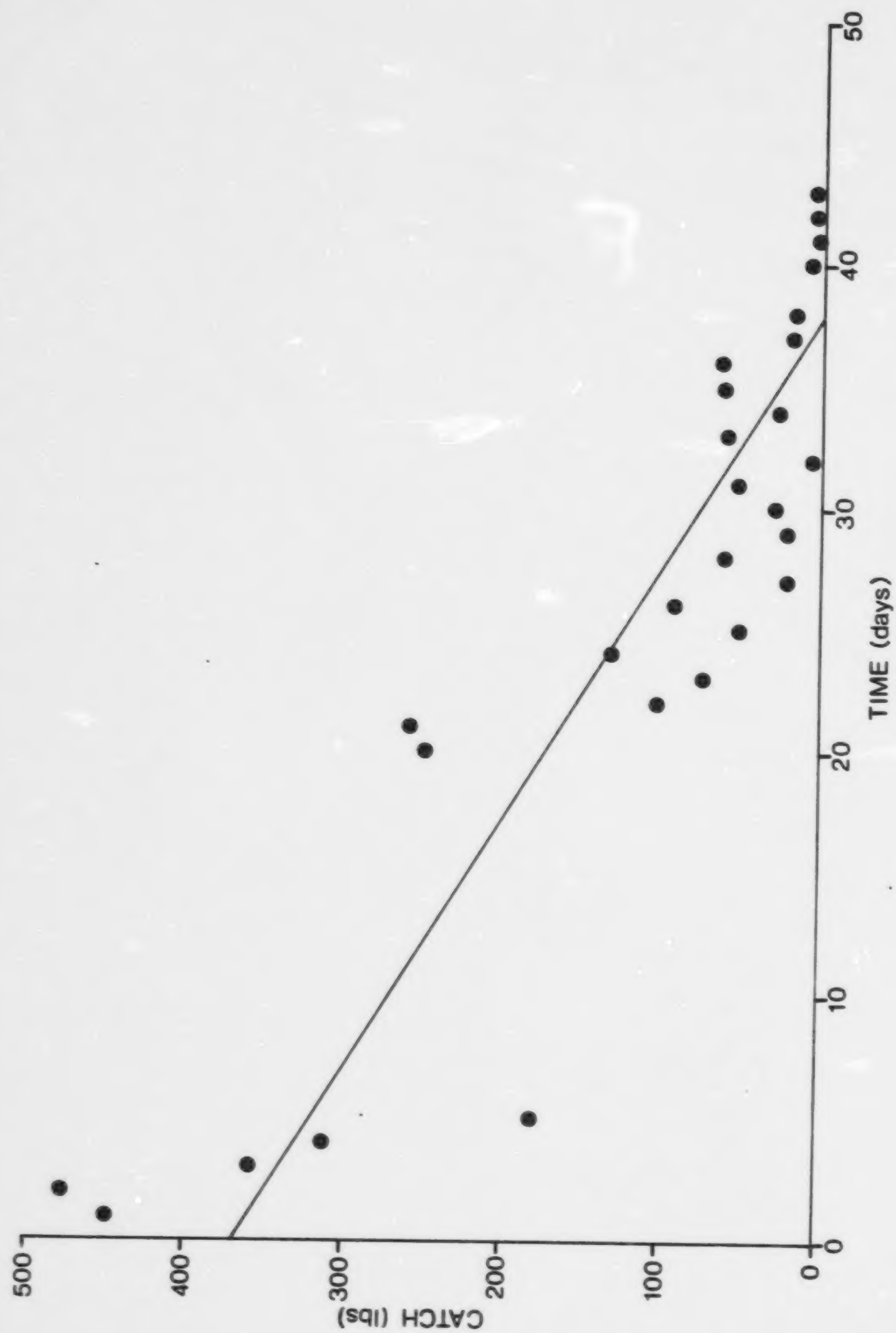

Fig. 93. Total daily catches of walleyes from Mackerracher I Lake.

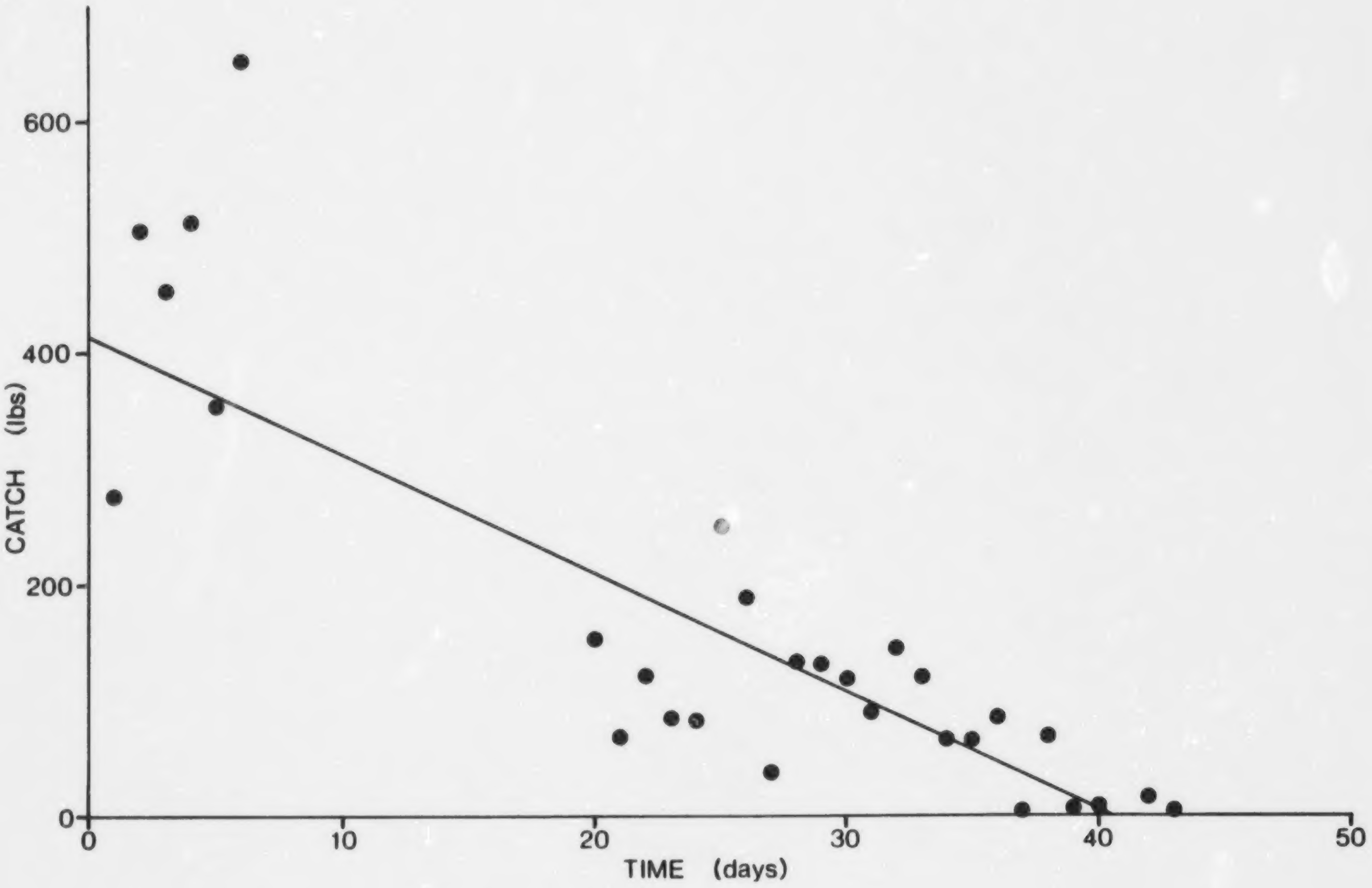

Fig. 94. Total daily catches of pike from Mackerracher I Lake.

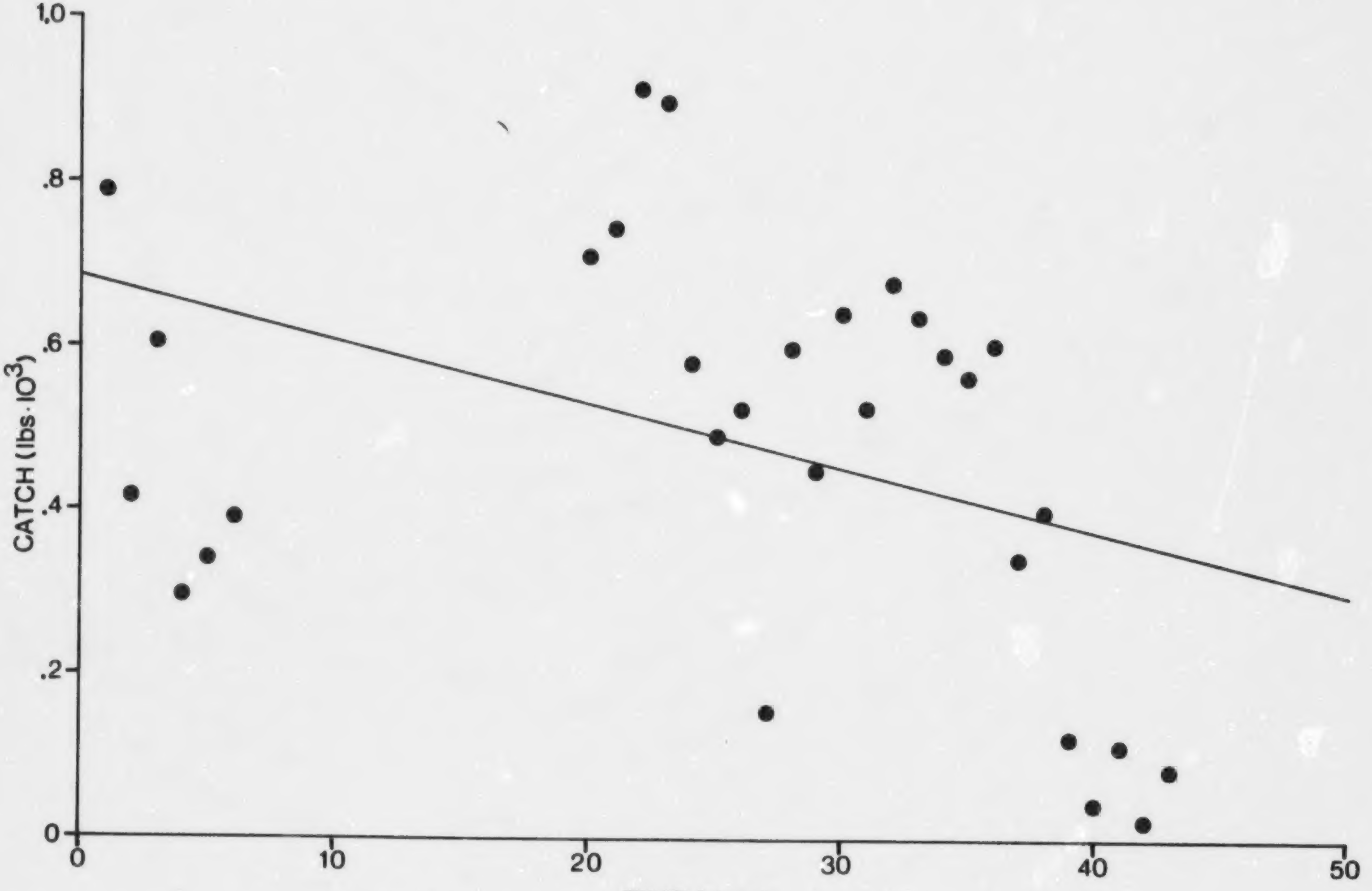

Fig. 95. Total daily catches of whitefish from Mackerracher I Lake.

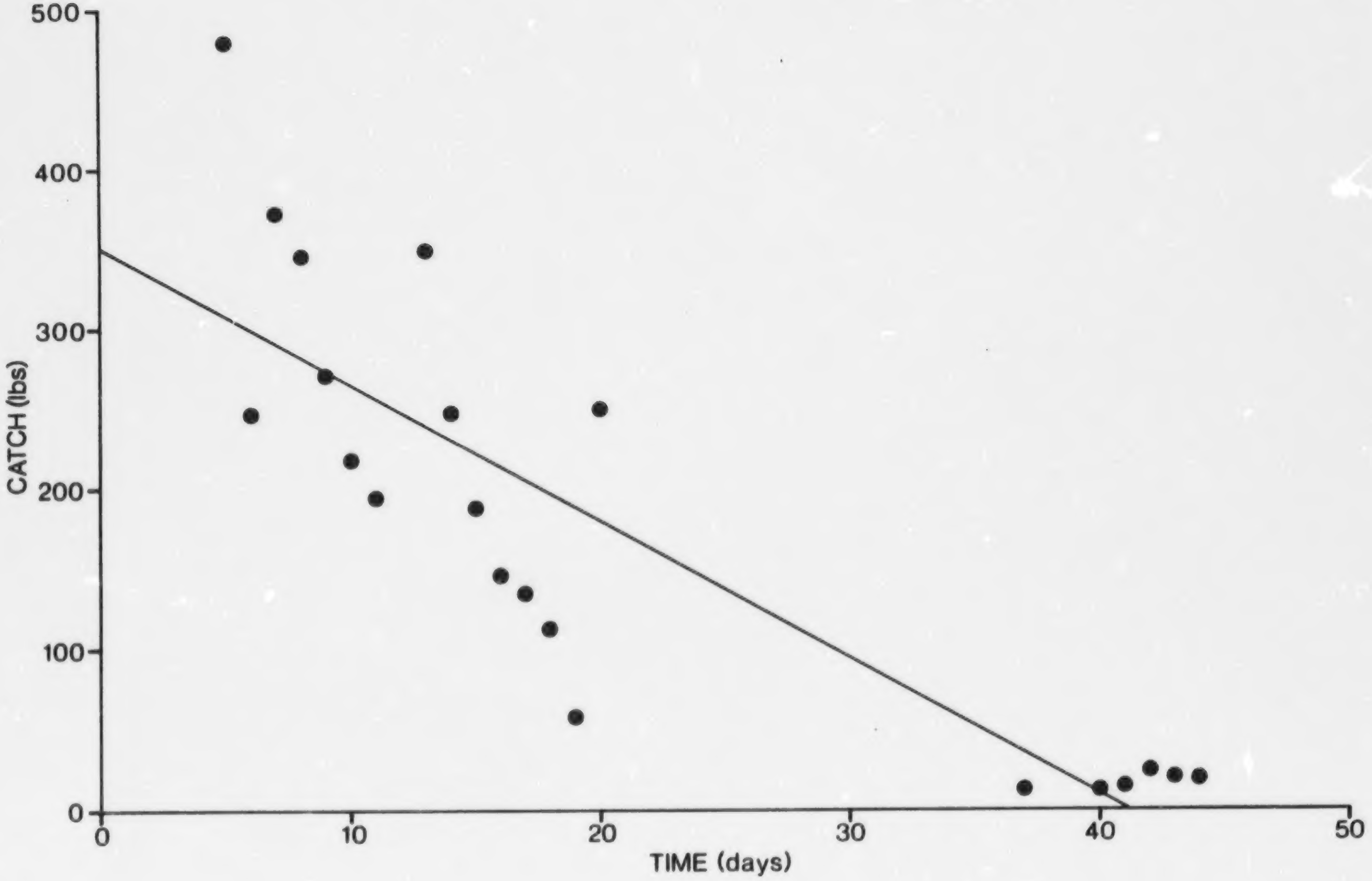

Fig. 96. Total daily catches of walleyes from Mackerracher II Lake.

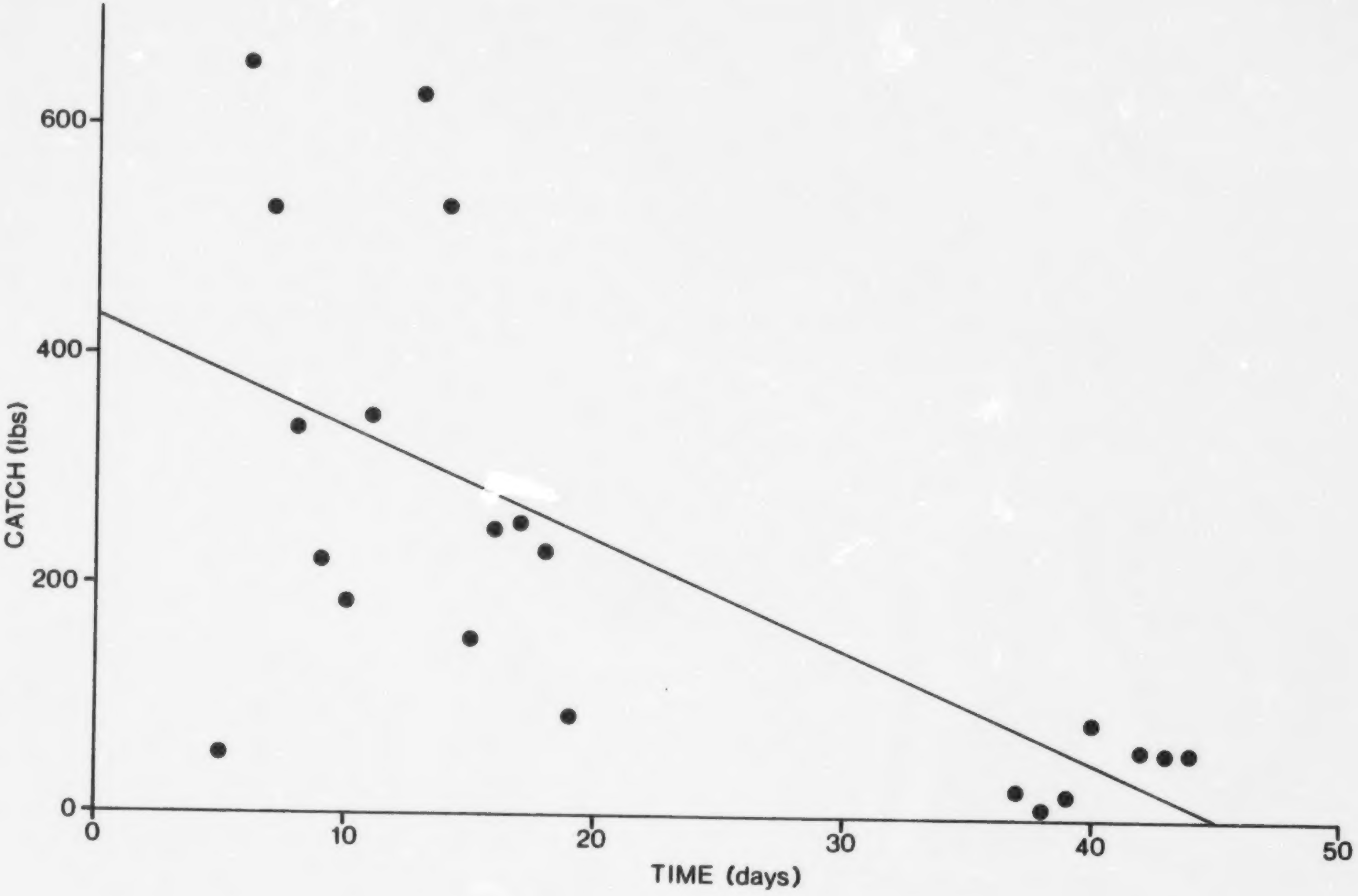

Fig. 97. Total daily catches of pike from Mackerracher II Lake.

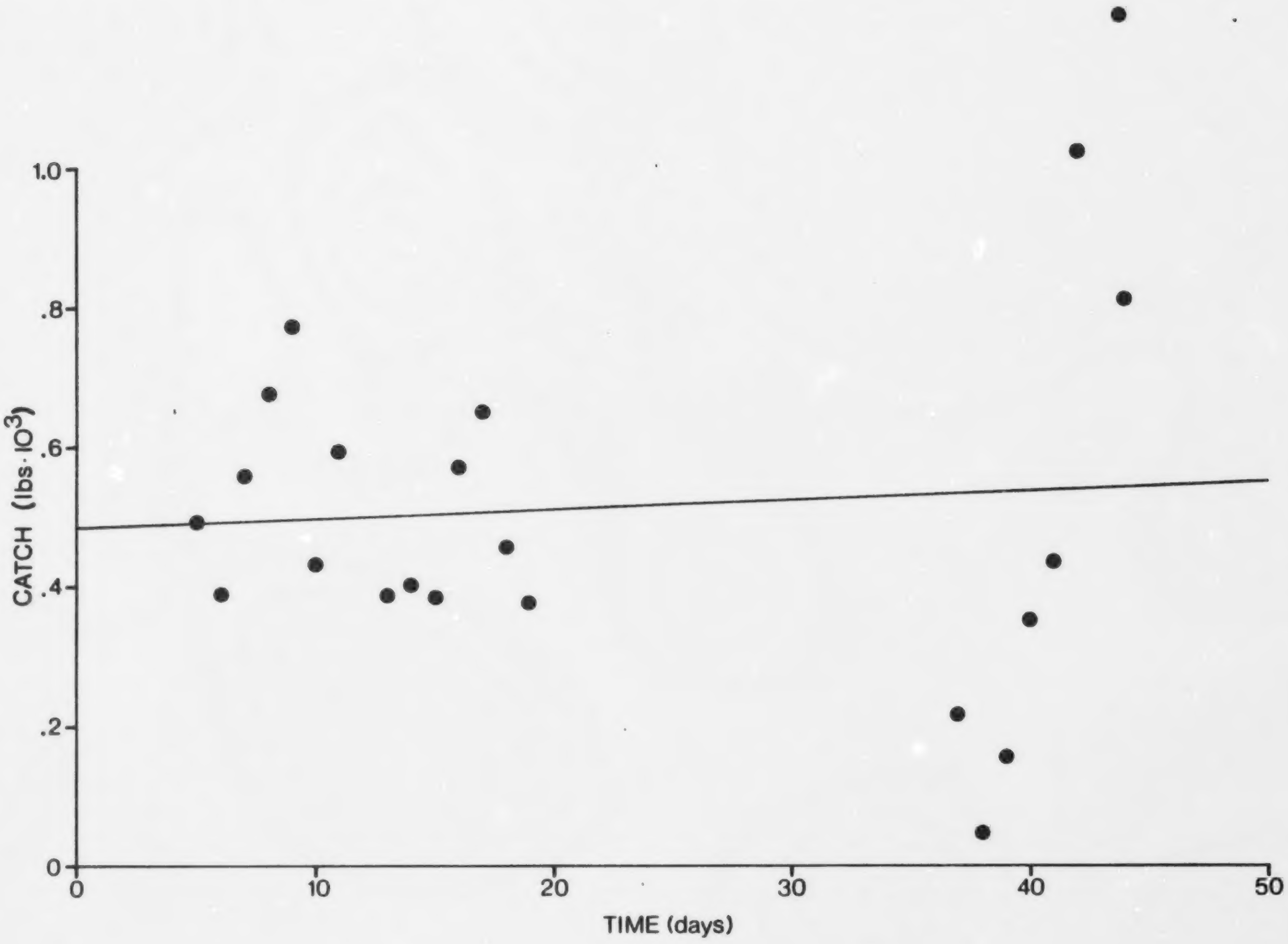

Fig. 98. Total daily catches of whitefish from Mackerracher II Lake.

Table 27. Regression analyses of Mackerracher Lake's commercial catch.

Lake and species	Number of days	Correlation coefficient	Linear equation	X-intercept (days)	Test F value
Mackerracher I					
walleye	28	-0.896	$Y = 368.983 - 9.74X$	37.5	105.89(1,26 d.f.)
whitefish	29	-0.389	$Y = 684.294 - 7.69X$	89	4.82(1,27 d.f.)
pike	28	-0.884	$Y = 415.028 - 10.25X$	40	92.84(1,26 d.f.)
all species	29	-0.847	$Y = 1467.635 - 27.64X$	53	68.27(1,27 d.f.)
Mackerracher II					
walleye	20	-0.858	$Y = 350.107 - 8.52X$	41	50.25(1,18 d.f.)
whitefish	22	-0.079	$Y = 483.378 + 1.42X$	-	0.13*(1,20 d.f.)
pike	21	-0.667	$Y = 432.162 - 9.59X$	45	15.24(1,19 d.f.)
all species	22	-0.597	$Y = 1267.644 - 16.88X$	75	11.07(1,20 d.f.)

* non-significant at $P = 0.05$

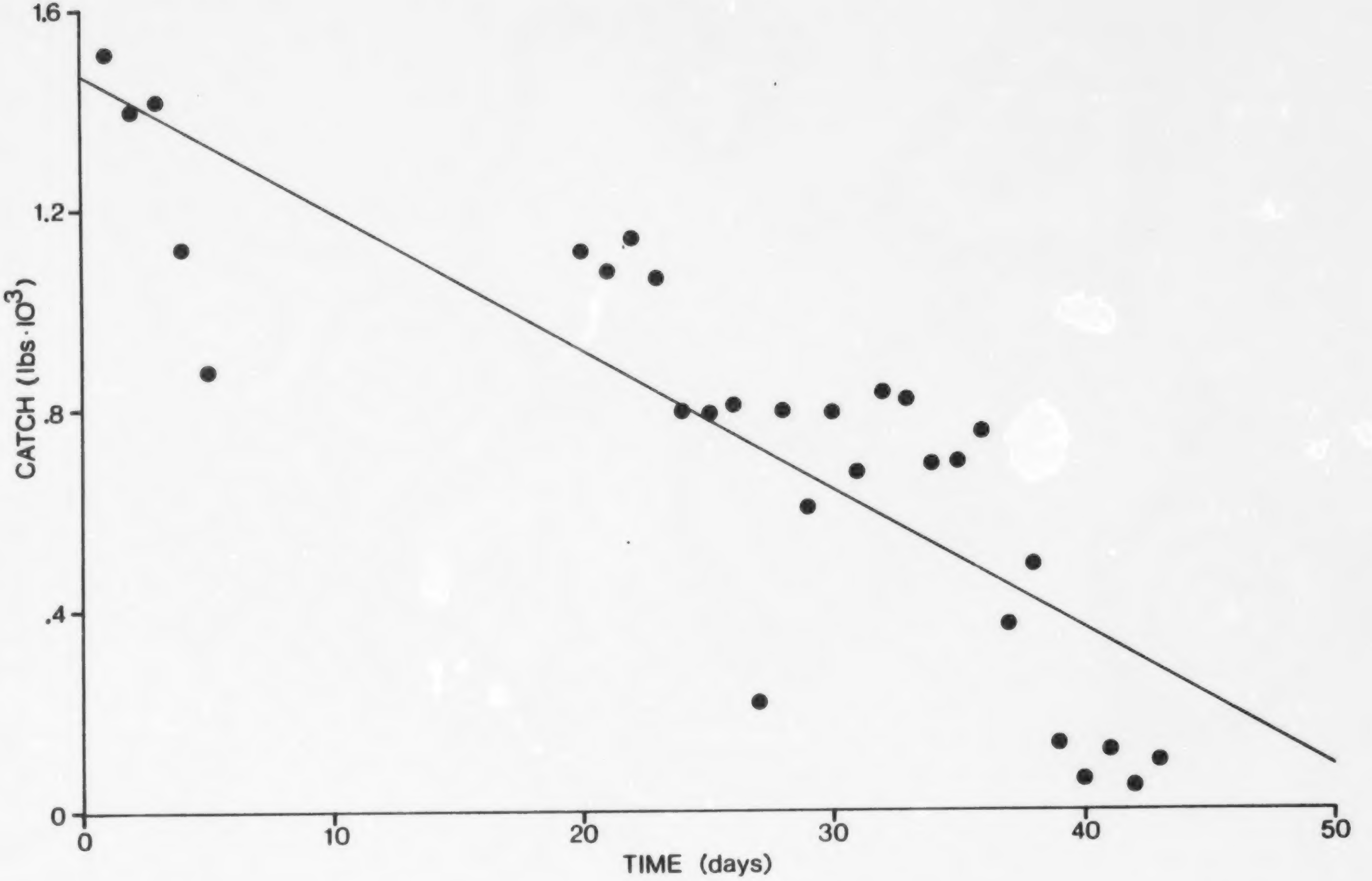

Fig. 99. Total daily catches of all species from Mackerracher I Lake.

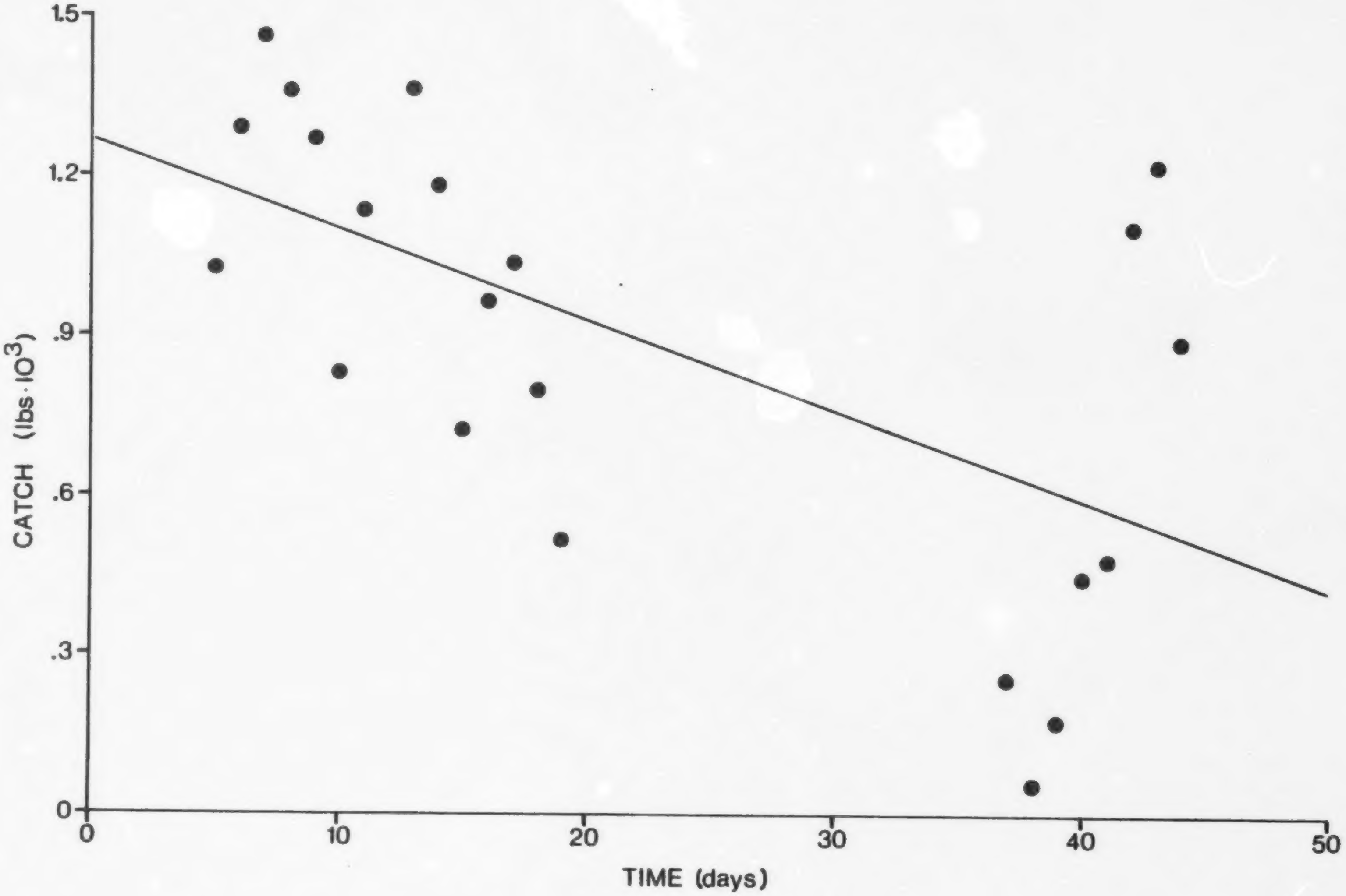

Fig. 100. Daily catches of all species from Mackerracher II Lake.

MacBride Lake

Daily catches of two groups of fishermen on MacBride Lake are listed on Table 28. Regression analyses of daily catches versus time showed all curves to be non-significant (Table 29).

Enatik I and II Lakes

Table 30 lists daily catches of two groups of fishermen on the Enatik Lakes. Correlation coefficients indicate a poor linear fit of daily catches and time. Almost all of the regressions were non-significant (Table 31). Commercial fishing on the Enatik Lakes was terminated because walleyes and pike contained too much mercury to be saleable.

Max Lake

The commercial operation on Max Lake ended before any temporal trends occurred in daily catches (Table 32).

Table 33 summarizes catches from all lakes that were commercially fished. Notice that fishing effort on Max Lake was almost three times stronger than on any other lake.

Table 34 compares yields predicted by the intensive fishing formula (Ryder 1965) to quotas and actual yields of commercially fished lakes. Actual yields were comprised only of walleyes, pike and whitefish. Actual yields were higher than quotas and predicted yields in all lakes except Max and MacBride lakes.

Trophic relationships

Since the weights of all species caught in each experimental gang

Table 28. Daily catches (lbs. dressed weight) of two groups of fishermen on MacBride Lake.

	Group no.									
	1					2				
Date	no. gangs	walleye	whitefish	pike	total	no. gangs	walleye	whitefish	pike	total
June 1	4	16	70	21	107	-	-	-	-	-
2	20	47	556	407	1010	8	45	126	196	367
3	11	8	463	120	591	4	8	53	59	120
4	22	19	490	294	803	18	39	84	235	358
5	24	4	243	54	301	15	28	55	185	268
6	12	35	222	169	426	8	23	47	120	190
7	12	82	296	155	533	8	87	69	205	361
8	12	72	5	156	233	8	32	3	169	204
totals	117	283	2345	1376	4004	69	262	437	1169	1868

Table 29. Regression analysis of MacBride Lake commercial catch.

Curve	Number of days	Correlation coefficient	Test F value
group 1, all species	8	-0.243	0.38* (1,6 d.f.)
group 2, all species	7	-0.137	0.10* (1,5 d.f.)
whitefish	8	-0.374	0.97* (1,6 d.f.)
catch unit effort^{-1}	8	-0.631	3.97* (1,6 d.f.)
all fish, all groups	8	-0.071	0.03* (1,6 d.f.)

*non-significant at P = 0.05

Table 30. Daily catches (lbs. dressed weight) of two groups of fishermen on Enatik I and II lakes.

Date	Group no.									
	1					2				
	no. gangs	walleye	whitefish	pike	total	no. gangs	walleye	whitefish	pike	total
Enatik I										
June 12	5		no data			5	no data			
13	9	82	115	250	447	6	128	80	299	507
14	9	27	315	8	350	6	40	135	48	223
15	18	162	1573	434	2169	12	80	229	230	539
16	27	28	903	42	973	14	43	359	92	494
17	9	24	391	40	455	14	48	314	37	399
18	9	82	372	0	454	7	24	126	12	162
19	9	38	367	77	482	7	13	46	15	74
20	—	no fishing		—	—	7	57	113	30	200
totals	90	443	4036	851	5330	73	433	1402	763	2598
Enatik II										
June 20	9	356	674	318	1348		no fishing			
21	9	179	1174	750	2103	4	23	306	200	529
22	9	79	829	440	1348	4	33	261	160	454
23	9	39	564	310	913	7	49	341	188	578
24		no fishing				7	80	323	116	519
25	9	259	371	298	928	8	76	463	100	639
26	9	254	175	254	683	9	35	614	80	729
27	9	343	423	202	968	10	151	814	60	1025
28	9	183	200	300	683	11	18	331	80	429
totals	72	1692	4410	2872	8974	60	465	3453	984	4902

Table 31. Regression analyses of Enatik I and II commercial catches.

Regression	Number of days	Correlation coefficient	Linear equation	Test F value
Enatik I				
all species, group 1	7	-0.165	Y = 961.6 - 50.04X	0.14(1,5 d.f.)
all species, group 2	8	-0.665	Y = 545.5 - 49.05X	4.75(1,6 d.f.)
walleye, all groups	8	-0.612	Y = 192.9 - 18.55X	3.60(1,6 d.f.)
whitefish, all groups	8	-0.265	Y = 959.8 - 62.24X	0.45(1,6 d.f.)
pike, all groups	8	-0.626	Y = 494.6 - 65.07X	3.88(1,6 d.f.)
all species, all groups	8	-0.455	Y =1647.36- 145.86X	1.56(1,6 d.f.)
catch unit effort^{-1}	8	-0.658	Y = 143.45 - 12.29X	4.57(1,6 d.f.)
Enatik II				
all species, group 1	8	-0.764	Y = 1736.8 - 123.0X	8.41*(1,6 d.f.)
all species, group 2	8	-0.413	positive slope	-
walleye, all groups	9	-0.407	positive slope	-
whitefish, all groups	9	-0.253	Y = 1038.17 - 32.9X	0.48(1,7 d.f.)
pike, all groups	9	-0.468	Y = 632.4 - 40.8X	1.96(1,7 d.f.)
all species, all groups	9	+0.063	positive slope	-
catch unit effort^{-1}	9	-0.445	Y = 274.6 - 15.71 X	1.73(1,7 d.f.)

* significant at P = 0.05

Table 32. Daily catches (lbs.) of three fishermen on Max Lake.

Date	No. gangs	Daily catch (lbs.)			
		walleye	whitefish	pike	total
Sept. 7	14	134	156	195	485
8	20	129	75	135	339
11	20	255	189	397	841
13	30	480	180	60	720
15	30	87	540	240	867
16	30	362	166	197	725
18	30	93	862	19	974
20	31	322	352	295	969
21	37	220	731	833	1784
24	37	60	180	120	360
Total	279	2142	3431	2491	8064

Table 33. Summary of commercial catches.

Parameter	Lake							
	Mackerracher		Denison	MacBride	Enatik		Max	Total
	I	II			I	II		
fishing period (days)	29	23	29	8	8	9	10	116
no. gangs	849	598	1200	186	163	132	279	3407
walleye (lbs.)	3202	3468	3552	545	876	2257	2142	16042
whitefish (lbs.)	13919	11334	23700	2782	5438	7863	3431	68467
pike (lbs)	4135	4752	2928	2545	1614	3856	2491	22321
Totals	21256	19554	30180	5872	7928	13976	8064	110237
mean catch/ gang/day (lbs)	0.863	1.422	0.867	3.946	6.080	11.764	2.89	
mean no. gangs/day	9.8	8.7	13.8	11.7	10.2	7.4	27.9	

Table 34. Predicted and actual yields and quotas of commercially fished lakes.

Lake	Predicted yield (lbs. year^{-1} lake^{-1})	Actual yield (lbs. round weight lake^{-1})	Quota (lbs.)
Denison	20050	41056	25000 combined with Mackerracher Lakes
MacBride	9572	7787	5000
Mackerracher I	19042	26259	see Denison
Mackerracher II	13872	24928	see Denison
Max	19724	8236	10000

were recorded and since each experimental gang was set for approximately the same duration, it was hypothesized that the mean weight per gang of all species caught in each lake may be considered as an index of fish biomass in that lake. It was further hypothesized that this index of biomass may be related to mean depth and [T.D.S.], the components of the M.E.I., and to the T.S.I.

Regression analyses of the mean catch per gang versus the mean depth, Z, of each lake listed on Table 35 revealed a dichotomy of lakes which was caused by differences in Z. The regression of mean catch per gang versus Z for all lakes was not significant (Fig. 101 curve A) but when the lakes were divided into "deep" (Fig. 101 curve B) and "shallow" (Fig. 101 curve D) groups, the regression of mean catch per gang and Z was significant for each group (Table 36). Deleting Willow Lake from the "deep" group significantly improved the correlation coefficient of the regression (Table 36, Fig. 101 curve C).

The mean catch per gang was not significantly related to [T.D.S] for deep and shallow lakes (Fig. 102, Table 36). Notice that some lakes switched categories from Fig. 101 to Fig. 102. Since mean catches per gang were not signficantly related to[T.D.S.], regressions of mean catches per gang and M.E.I. were negatively correlated for both groups of lakes and were not significant except for curve E in Fig. 103 (Table 36).

Mean catches per gang increased with increasing conductivity in deep and shallow lakes (Fig. 104). A significant relationship of mean catch per gang and conductivity existed for shallow lakes but not for deep lakes (Table 36). Since [T.D.S.] and conductivity are positively correlated, one would expect mean catch per gang to increase with

Table 35. Parameters used in derivations of trophic relationships.

Lake	Mean biomass per gang (kg)	Mean depth (m)	Mean T.D.S. (mg l^{-1})	Mean conductivity (µmho cm^{-1})	T.S.I. (SD)	M.E.I.	Mean biomass $gang^{-1}$ mean $depth^{-1}$ (kg m^{-1})
MacBride	63.52	4.28	80.3	68.2	58.9	18.76	14.84
Enatik	82.56[t]		43.7[t]	75.6[t]	55.9[t]		
Mackerracher I	105.11	4.19	58.3	84.3	51.3	11.23	20.25
MackerracherII	100.84	5.25	43	100.6	50.0	8.19	19.21
Denison	36.67[a.]	4.84	41.3	86.8	50.0	8.53	7.58
Wass	81.36	4.45	83.7	88.3	51.5	18.81	18.28
Willow	70.3	14.07	71.7	103.03	54.2	5.1	5.00
Cuddle	51.12	7.79	73	85.73	52.3	9.37	6.56
Bearhead	50.68	2.08	77	83.17	53.2	37.02	24.37
Aswapiswanan	49.36	2.80	77.3	101.17	48	27.61	17.63
Whitefish	77.26	2.90	62.3	87.13	47.19	21.48	26.64
Max	29.88	4.40	62.7	84.1	43.7	14.25	6.79
Ankle	59.57	7.10	50.3	65.07	48	7.08	8.39
Semple	73.46	1.55	78.7	87.73	53.3	50.77	47.39
Fairy Rock	48.7	6.55	89*	92.3	52.7	13.59	7.44

* estimated from a multiple regression of T.D.S. on conductivity and temperature.

[t] mean of values from the two lakes.

[a.] determined from only 1 gang

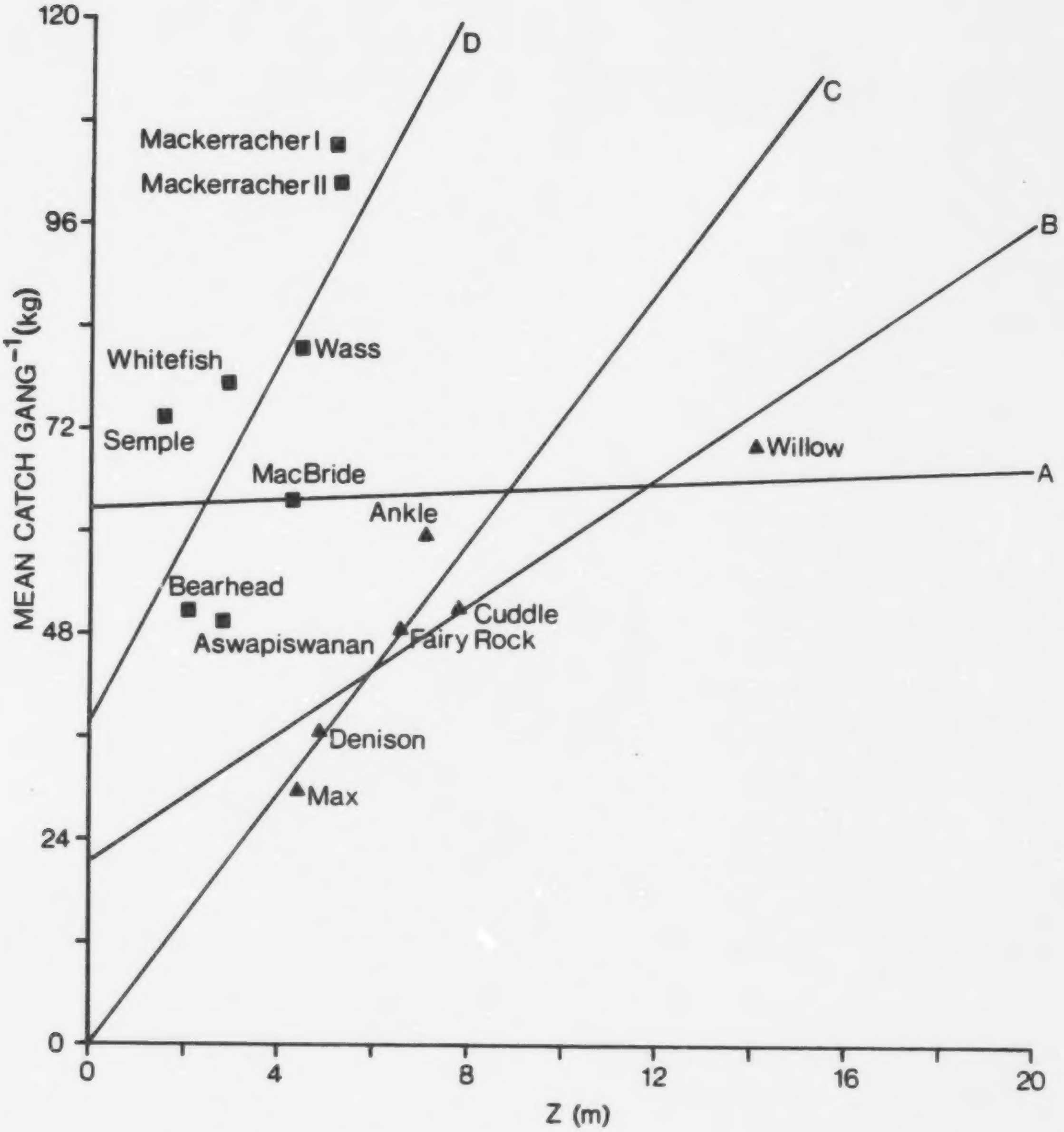

Fig. 101. Relationship of mean catch per gang and mean depth. Curve A- all lakes, curve B- deep lakes, curve C- deep lakes omitting Willow L., curve D- shallow lakes.

Table 36. Regression analyses of trophic state relationships.

Relationship	Equation	R	Test F value and d.f.
mean catch gang^{-1} and Z			
all lakes	Y = 62.853 + 0.244X	0.34	0.01(1,12)
deep lakes	Y = 21.395 + 3.751X	.889	15.02(1, 4)*
deep lakes except Willow lake	Y = 0.052 + 7.356X	.907	13.89(1,3)*
shallow lakes	Y = 37.914 + 10.466X	.716	6.32(1, 6)*
mean catch gang^{-1} and [T.D.S.]			
shallow lakes	Y = 19.682 + 0.404X	.477	1.47(1, 5)
deep lakes	Y = 102.531 - 0.353X	.364	0.92(1, 6)
mean catch gang^{-1} and M.E.I.			
all lakes	Y = 65.432 - 0.072X	.042	0.02(1,12)
deep lakes	Y = 58.542 - 0.640X	.218	0.25(1, 5)
deep lakes except MacBride Lake	Y = 74.486 - 2.534X	.685	3.53(1, 4)
shallow lakes	Y = 96.782 - 0.891X	.602	3.41(1, 6)
shallow lakes except Semple Lake	Y = 117.563 - 2.060X	.896	20.44(1, 5)*
mean catch gang^{-1} and conductivity			
all lakes	Y = 48,946 + 0.190X	.095	0.12(1,13)
deep lakes	Y = -45.985 + 1.035X	.667	4.01(1, 5)
shallow lakes	Y =-0.884 + 0.991X	.724	6.62(1, 6)*
mean catch gang^{-1} and T.S.I.			
all lakes	Y = 17.021 + 1.604X	.276	1.07(1,13)
shallow lakes	Y = 64.047 + 0.336X	.066	0.03 (1,6)
deep lakes	Y = -57.484 + 2.041X	.888	18.62(1, 5)*
$\log_e$ mean catch gang^{-1} and T.S.I.			
all lakes	Y = 2.326 + 0.035X	.371	2.07(1,13)
shallow lakes	Y = 4.042 + 0.007X	.107	0.07(1, 6)
deep lakes	Y = 1.482 + 0.046X	.873	15.96(1, 5)*

mean catch gang^{-1}Z^{-1} and T.S.I.			
all lakes	$Y = -4.346 + 0.408X$	.131	0.21(1,12)
shallow lakes	$Y = -74.029 + 1.952X$	.444	1.23(1, 5)
deep lakes	$Y = -10.149 + 0.355X$	.541	2.07(1, 5)
$\log_e$ mean catch gang^{-1}Z^{-1} and T.S.I.			
all lakes	$Y = 1.619 + 0.019X$	.106	0.14(1,12)
shallow lakes	$Y = 0.034 + 0.062X$	.425	1.10(1, 5)
deep lakes	$Y = 0.481 + 0.030X$	.438	1.19(1, 5)

* significant at $P = 0.05$

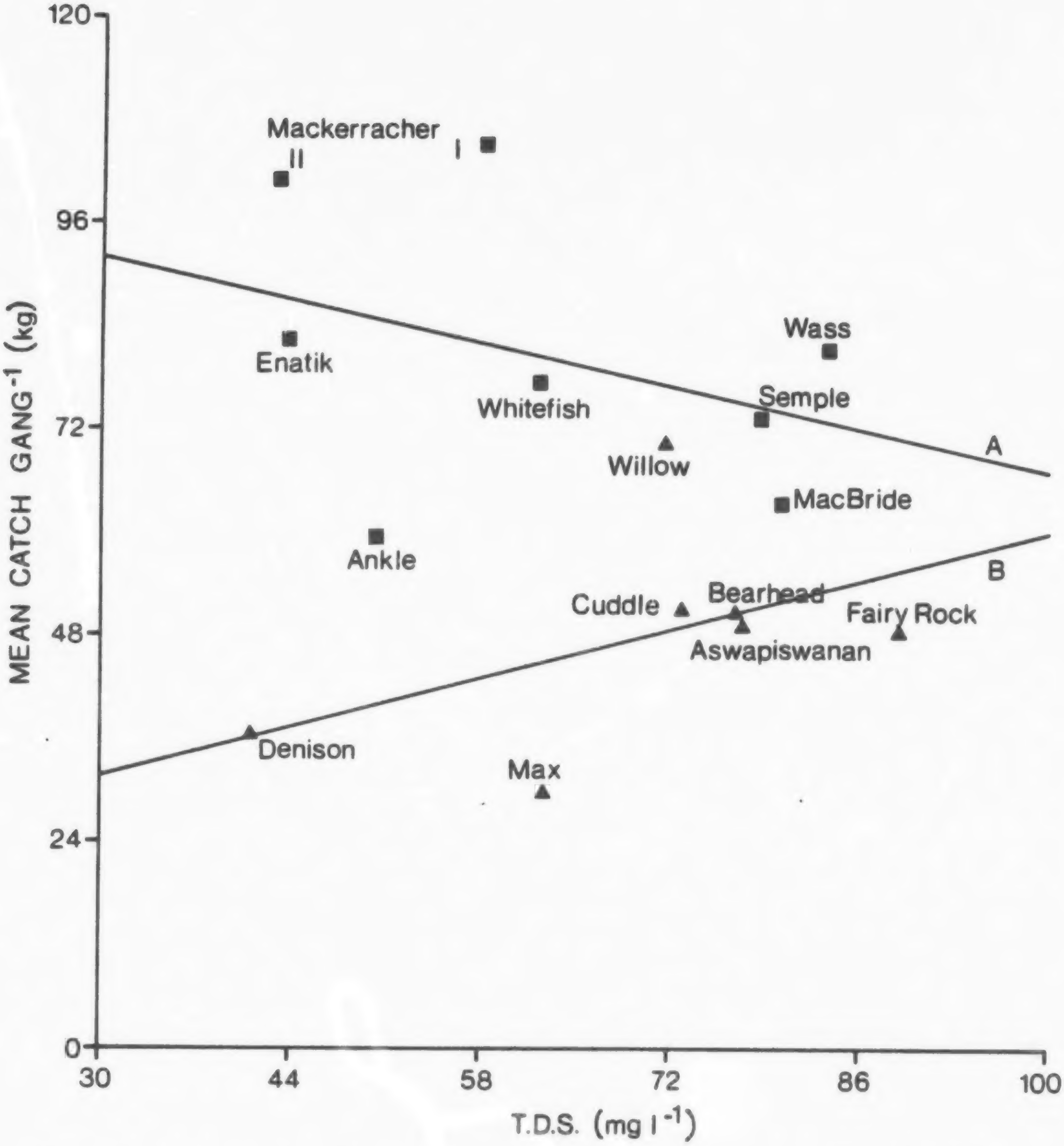

Fig. I02. Relationship of mean catch per gang and [T.D.S.] for shallow lakes (curve A) and deep lakes (curve B).

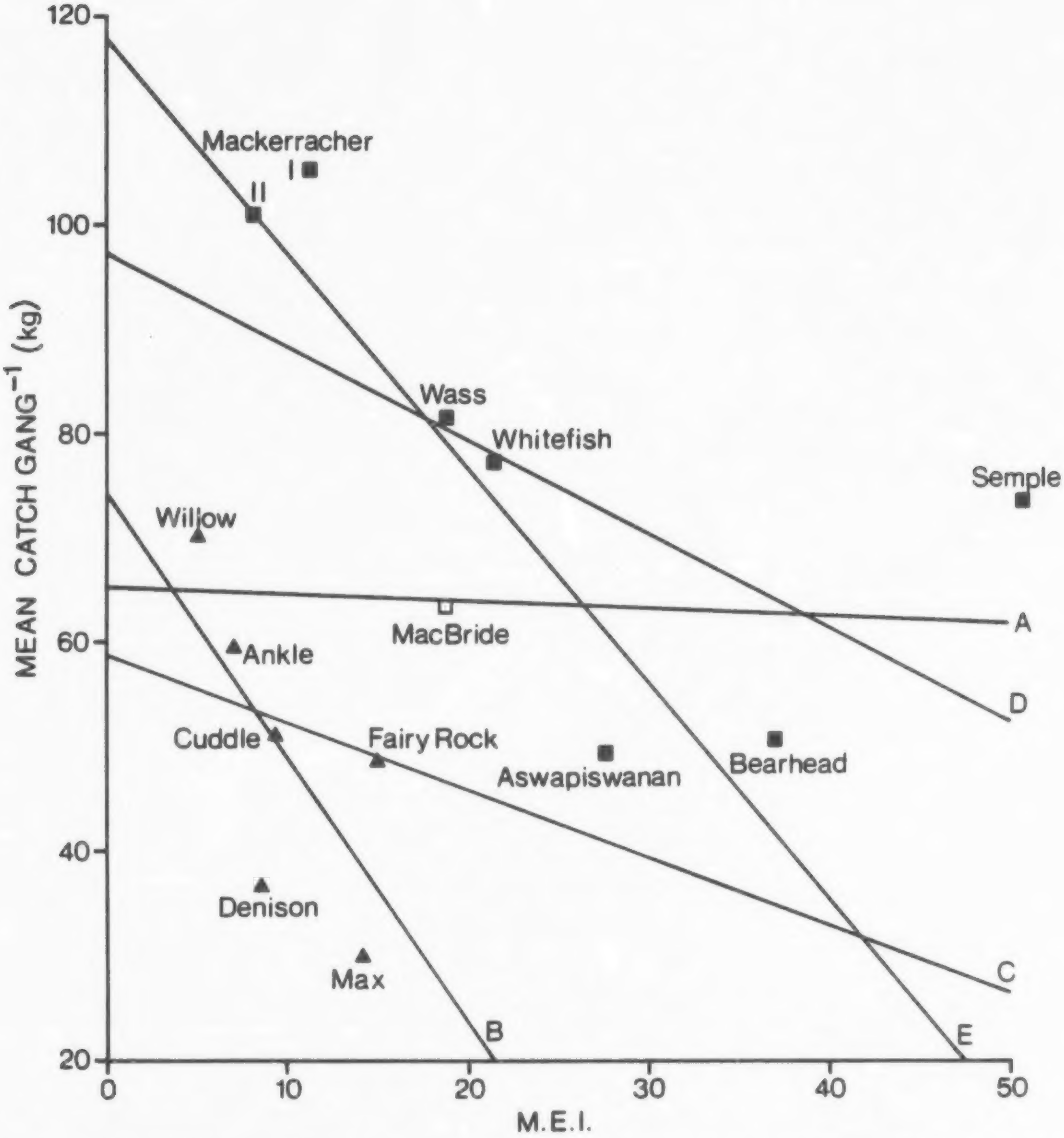

Fig. I03. Relationship of mean catch per gang and M.E.I. Curve A- all lakes, curve B- deep lakes, curve C- deep lakes omitting MacBride L., curve D- shallow lakes, curve E- shallow lakes omitting Senple L.

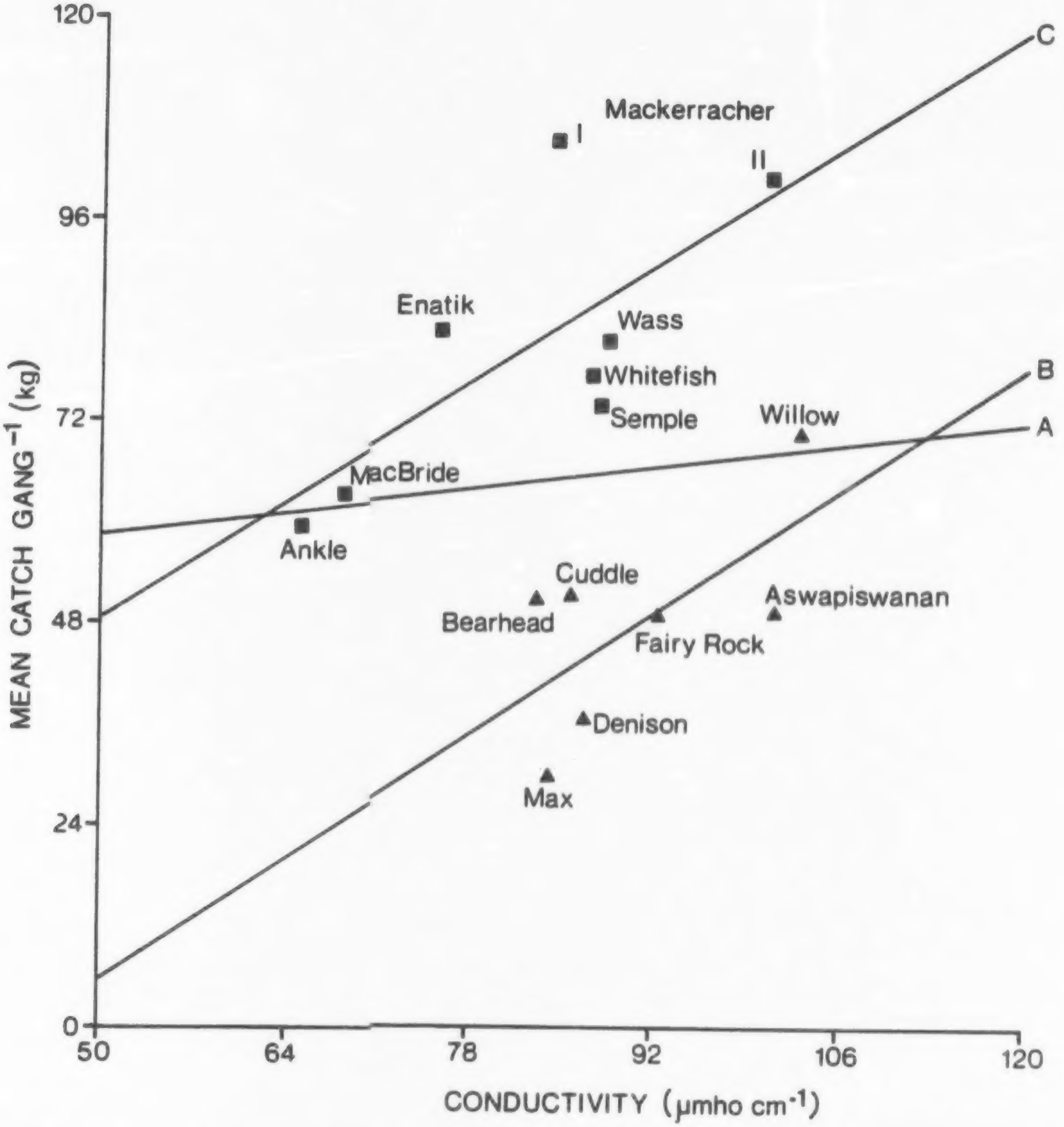

Fig. I04. Relationship of mean catch per gang and conductivity of lake waters. Curve A- all lakes, curve B- deep lakes, curve C- shallow lakes.

increasing conductivity but this did not occur (Fig. 102).

Mean catches per gang and trophic state indices were not significantly correlated for shallow lakes but were significantly related for deep lakes (Fig. 105, Table 36). Semilog transformations did not improve the regression of mean catch per gang and T.S.I. for shallow lakes (Fig. 106, Table 36). Untransformed and semilog transformed regressions of mean catches per gang corrected for Z versus trophic state indices were not significant for deep or shallow lakes (Figs. 107, 108, Table 36).

A multivariate analysis of covariance of mean catch per gang versus mean depth, X_1, and mean conductivity, X_2, for deep and shallow lakes yielded the following information:

a. significant differences exist between the mean catches per gang and between the mean depths of the shallow and deep groups of lakes but the mean conductivity of the shallow group of lakes is almost identical to that of the deep group.

b. nevertheless significant differences exist between the regression planes of mean catch per gang versus Z and conductivity of deep and shallow lakes when the planes are compared over common ranges of Z and conductivity (Appendix E).

c. The linear multiple regression line of catch versus Z and conductivity is $Y = 58.021 + 4.739X_1 - 0.511\ X_2$ for deep lakes and is $Y = 11.732 + 10.476X_1 + 0.299\ X_2$ for shallow lakes. Conductivity does not significantly increase the predictive ability of both equations ($F = 6.52$, 1 and 4 d.f. for deep lakes and $F = 0.29$, 1 and 6 d.f. for shallow lakes).

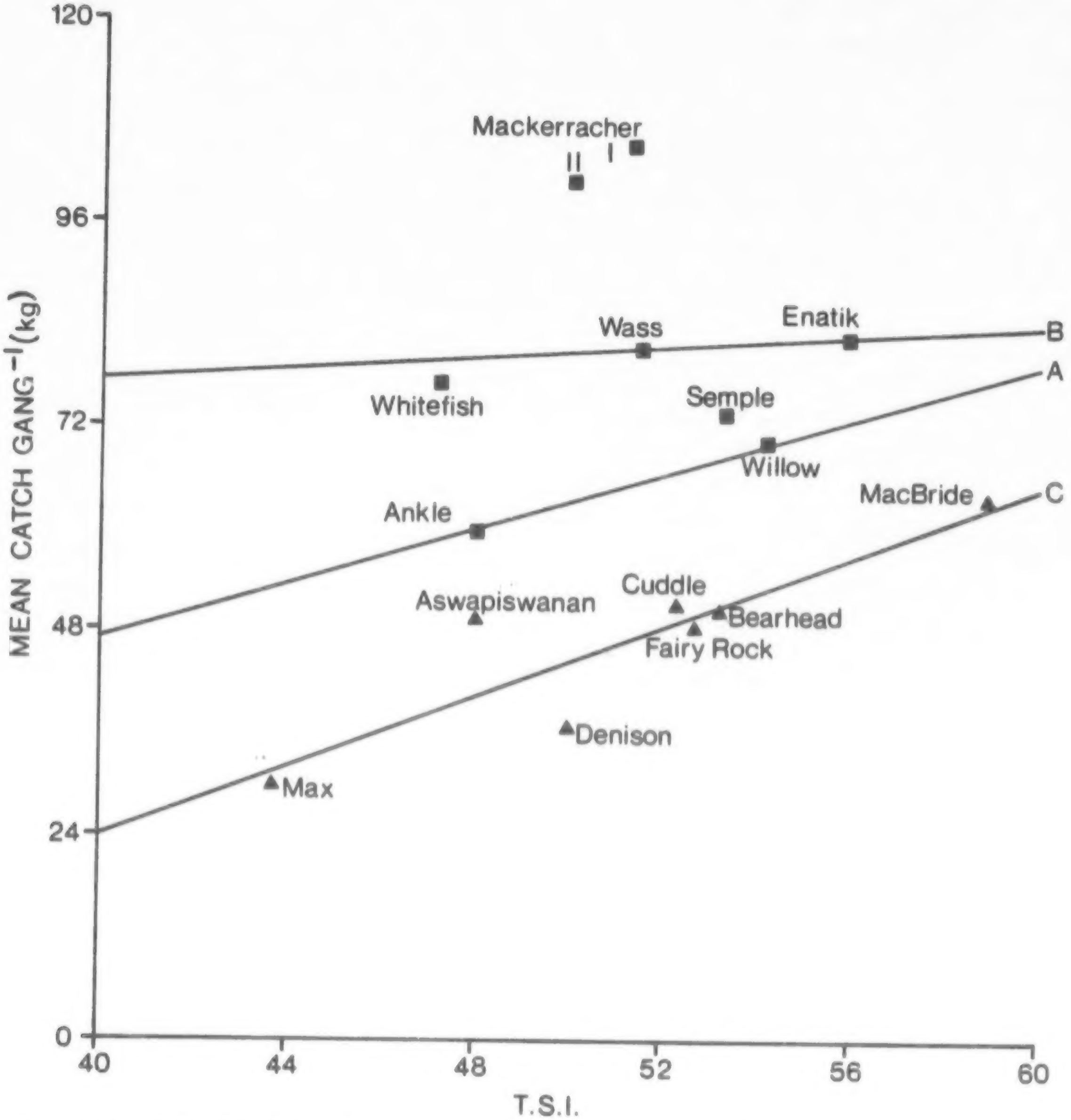

Fig. I05. Relationship of mean catch per gang and trophic state indices for all lakes (curve A), shallow lakes (curve B), and deep lakes (curve C).

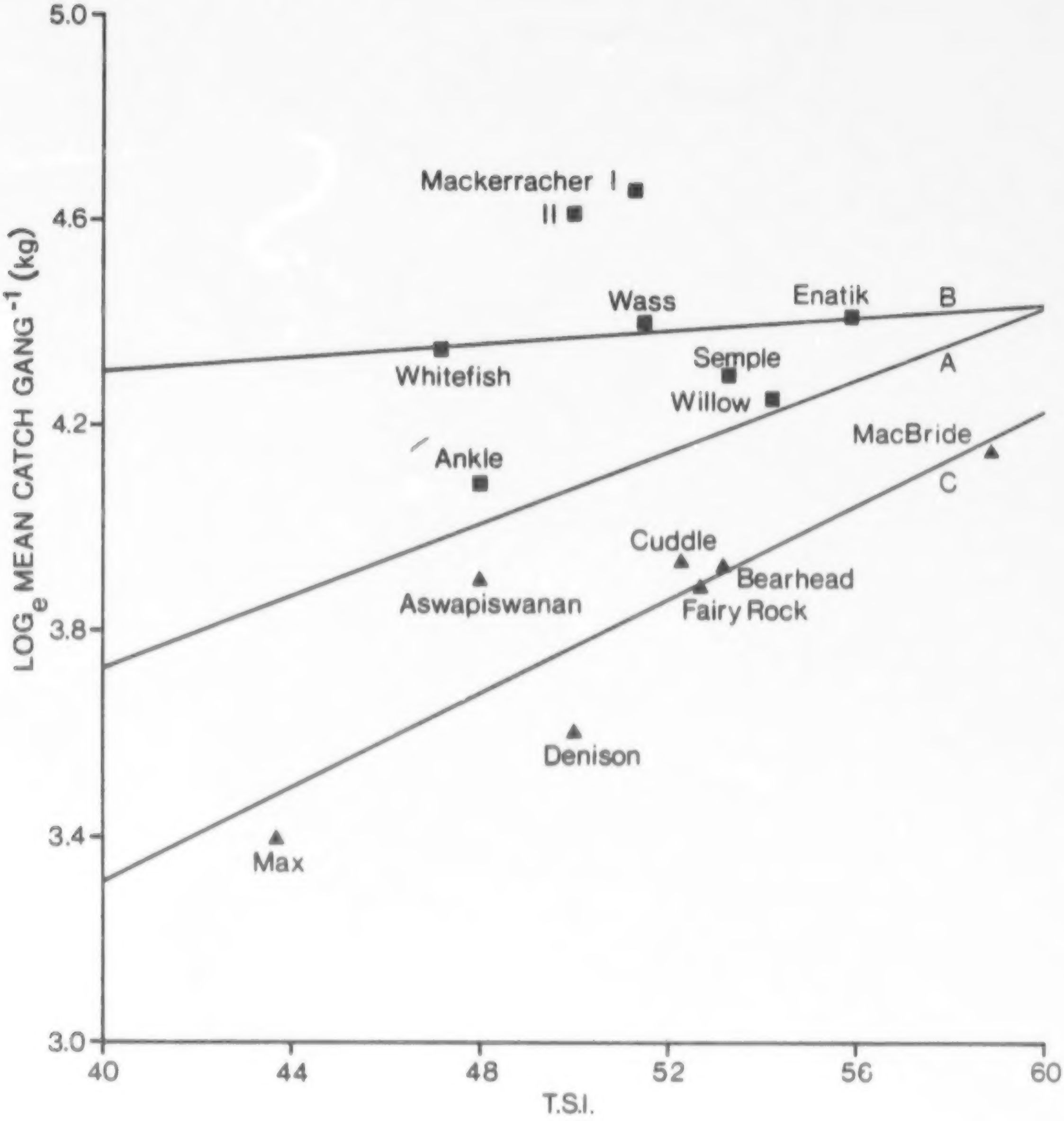

Fig. 106. Relationship of the log of the mean catches per gang and trophic state indices. Curve A- all lakes, curve B- shallow lakes, curve C- deep lakes.

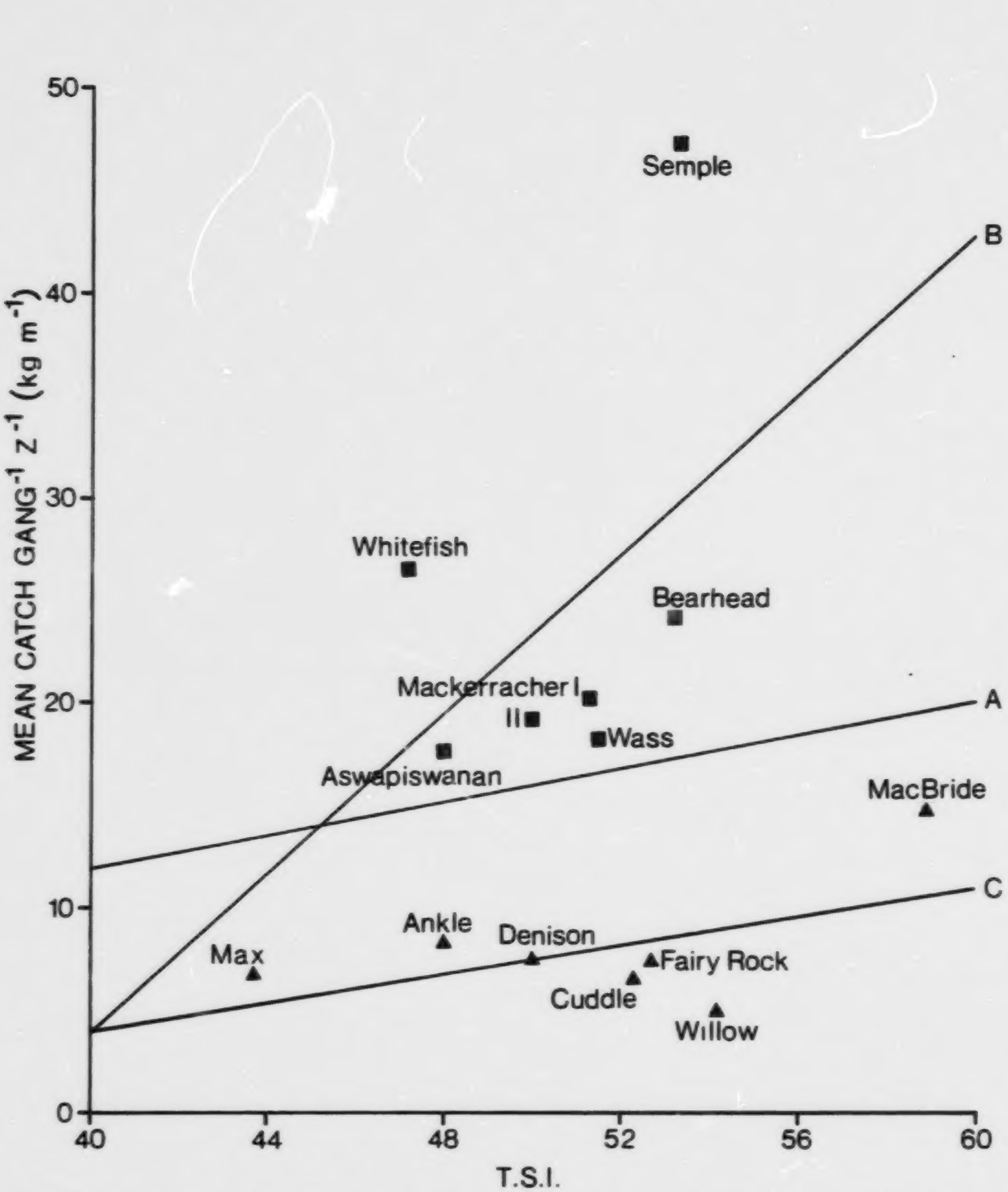

Fig. I07. Relationship of mean catch per gang corrected for mean depth and trophic state indices. Curve A- all lakes, curve B- shallow lakes, curve C-deep lakes.

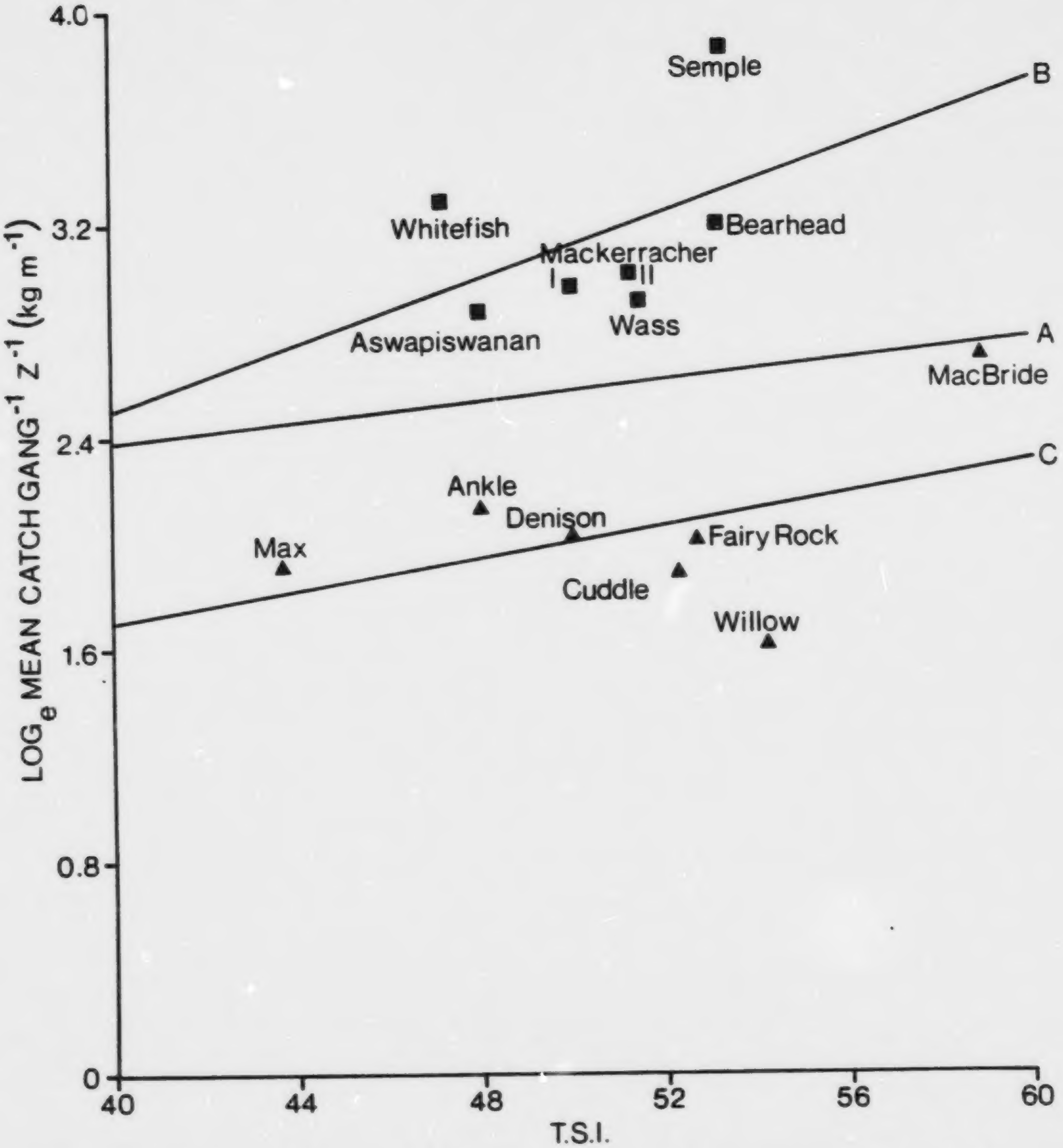

Fig. I08. Relationship of the log of mean catch per gang corrected for mean depth and trophic state indices. Curve A- all lakes, curve B- shallow lakes, curve C- deep lakes.

DISCUSSION

Limnological sampling

The trophic state index provides a relative trophic classification of lakes as opposed to the more discrete traditional oligo-meso-eutrophic classes (Carlson 1977). In this study, the calculation of one trophic state index based on Secchi disc transparency and another TSI based on total phosphorus concentrations provided slightly different trophic classifications for the same lake. Carlson (1977) stated that Secchi disc transparency would probably yield an erroneous TSI in lakes that:

1. contain high levels of non-algal particulate matter
2. are highly colored
3. are extremely clear

The accuracy of a TSI based on total phosphorus concentration depends on the following assumptions:

1. phosphorus is the major limiting factor of algal growth
2. concentrations of all forms of phosphorus present are a function of algal biomass.

Carlson (1977) states that the first assumption is valid only in summer. The second assumption is not valid for lakes with high orthophosphorus concentrations or for highly colored lakes where some forms of phosphorus may be incorporated into humic acids. For example, Grandmother Lake is characterized by high color, turbidity and [P] and a low transparency. The TSI values of Grandmother Lake are high and suspect due to high turbidity and color.

The trophic state indices based on [P] were not useful in ranking lakes because phosphorus concentrations less than 20 mg m^{-3} were not detected by the Environmental Management Laboratory. The techniques used by this laboratory in determining [P] should be refined to provide more accurate measurements of low [P] since most shield lakes are characterized by low [P].

Fish sampling

The presence of saugers in Aswapiswanan, Wass and Willow Lakes confirms the northern boundary of sauger distribution in Manitoba shown in Scott and Crossman (1973). The presence of emerald shiners in Whitefish, Aswapiswanan, and Fairy Rock Lakes extends the previous distribution of emerald shiners in Manitoba shown in Scott and Crossman (1973) to the north and east.

Lakes sampled in 1978 that contained export quality whitefish (<40 cysts cwt^{-1}) were all in the vicinity of the 4AF watershed division while lakes containing lower quality whitefish were south and west of the 4AF watershed division.

Gillnet selectivity affects slopes of length-weight curves. The youngest fish caught in nets usually have high weight to length ratios implying that they lie above the true length-weight curve. The points on the length-weight curves presented in this report are age-specific mean lengths and mean weights. Thus the derived equations describe the "age class length-weight relationship". A line fitted through individual lengths and weights would predict smaller weights at a given length. In spite of this, age class length-weight relationships may be used to compare relative differences among populations from different lakes. Most of the walleye and whitefish populations were characterized by length-weight curves whose slopes were greater than those of their Lake Winnipeg counterparts. These differences may be due to differences in exploitation. Hanford *et al.* (1977) suggest that since gillnets remove large, proportionately fat fish, selective pressures operate to favour proportionately thinner fish. Thus, slopes of length-weight curves of Lake Winnipeg stocks may be lower because Lake Winnipeg is heavily exploited (Lysack 1981).

The mean L_∞ of walleyes in this study, 533 mm, is slightly higher than that of northern Lake Winnipeg walleyes. Conversely, the mean L_∞ of whitefish in this study, 468 mm, is less than that of its Lake Winnipeg counterpart. Pike populations in this study displayed a dichotomy of L_∞ estimates. Gillnet selectivity for larger body sizes of younger fish depresses the left end of Walford plots (Ricker 1975). Accordingly, such points were deleted from Walford plots in this study. In some cases, deletion of successive mean lengths of older fish which were obvious anomalies decreased slopes of Walford plots from above unity to below unity and thus allowed L_∞ to be estimated. Such aberrent mean lengths were usually derived from age classes comprised of fewer than five fish.

Growth rates of all three species in this study were highly variable among lakes irrespective of the type of growth model employed (Table 15). Healey (1975, 1980) stated that variability in whitefish growth increases with decreasing exploitation. The von Bertalanffy model provided more precise estimates of growth than the exponential model. Stepwise ANCOVA was used to create groups of populations exhibiting similar Brody growth coefficients in this study. Growth was more variable among walleye populations and among pike populations than it was among whitefish populations (Tables 16 - 18). Lake groupings were not consistent among species, i.e. the fastest growing pike, walleye and whitefish populations did not occur in a mutually inclusive group of lakes. This was confounded by significant differences in elevations of the growth curves.

Healey (1975) stated that mortality rates and growth rates of whitefish are positively correlated over a wide range of climates but not within any one climatological area. In this study growth rates were not significantly correlated to mortality rates of walleyes, whitefish and pike from all of the lakes but the relationship did exist for populations inhabiting some of the lakes in the "deep" category shown in Fig. 101.

Abrasov's (1967) corrected formula (Lysack 1980) consistently overestimated the mean age of maturity of all species in this study. Errors in estimating the mean age of maturity be Abrasov's formula are caused not only by aberrant $A_n (K_n - K_{n-1})$ values but also by differences in sizes and ages of fish recruited to gillnets. The use of fitted maturity curves not only eliminates these errors but also provides estimates of instantaneous maturity rates. These rates may differ among lakes while Abrasov's mean age of maturity remains relatively static. Stepwise ANCOVA did not reveal any significant differences among instantaneous maturity rates of walleye and whitefish populations. Pike from Cuddle Lake matured at a significantly slower rate than any other pike populations. However, the maturity versus age regression for Cuddle Lake pike was not significant at $P = 0.05$ (Table 20).

The commercial fishing phase of the pulse fishing project was an utter failure because:

1. the fishermen who participated in 1977 exerted very little fishing effort. This effort was not temporally or spatially constant.

2. the fishermen were not allowed to use smaller mesh nets. Thus, they simply cropped some of the older fish and probably did not initiate compensatory changes in growth and maturity rates.
3. The project was terminated before it was possible to assess the effects of commercial fishing on the fish populations.
4. in most cases, operational costs exceeded income from fishing (Appendix F).
5. lakes contained low quality fish.

Ryder's (1965) formula predicts commercial fishing yield as a function of the M.E.I. which is comprised of mean depth and [T.D.S.]. Such an equation requires a rather long data series on commercial fishing yields. In this study, it was demonstrated that the same type of equation can probably be formulated by regressing mean catch gang^{-1} unit time^{-1} on Z and [T.D.S.] for deep and shallow lakes. Z contributes substantially more to such an equation than does [T.D.S.].

Methodological errors in measuring [T.D.S.] precluded the formulation of a predictive equation relating catch and M.E.I. The attempt to model catch as a function of Z and conductivity failed because conductivity is temperature specific and is a rather poor indicator of [T.D.S.] in this case. Since there is no formula currently in existence that relates [T.D.S.] to conductivity and temperature for northern Manitoba Lakes, it was impossible to convert conductivity to [T.D.S.].

The mean catch gang^{-1} was highly correlated to the T.S.I. in deep lakes but not in shallow lakes (Table 36). This T.S.I. was based on measurements of Secchi disc transparency. The transparency of shallow lakes was probably more affected by non-algal particulate matter than it was in deeper lakes and thus reflected the trophic status of shallow lakes less than it did in deeper lakes. Correcting mean catches for the mean depth of lakes did not improve the relation of catch and T.S.I. Unfortunately total P would not be determined for lakes with $P < 20$ mg m^{-3} which precluded the use of trophic state indices based on [P].

RECOMMENDATIONS

1. In the event that a pulse fishing project is considered in the future, the following recommendations should be considered:
    a. to offset high transportation costs, only lakes that contain high quality whitefish and walleyes and that are close to fish packing facilities should be considered.
    b. fishermen should not be paid to participate since this ultimately decreases the amount of fishing effort they exert. Highly industrious individuals should be chosen.
    c. Some of the lakes should be fished with smaller mesh nets to determine the effects of mesh size on stimulating compensatory changes in growth and mortality of fish populations.
    d. lakes that have been commercially fished should be surveyed two or three years later.
2. The relationship of catch gang^{-1} and morphoedaphic factors and trophic state indices should be further developed and refined as follows:
    a. examine the relationship for a larger group of lakes that covers a wider range of Z and [T.D.S.].
    b. determine if species composition affects the equation.
    c. determine if catches are related to trophic state indices based on [P] and on [chlorophyll A].
    d. determine the relationship using mean catch per commercial gang as opposed to experimental gangs.

ACKNOWLEDGMENTS

Sincere appreciation is extended to Jacek Patalas, Laura Ross, Bill Golke and Gerry Spence for their efforts in 1978. Jo Sigurdson, Al Friesen, George Adams, Gord Prouse and Ken Hill provided valuable advice in the field. Don Cook and staff made sure that the field crew was well fed and that the twin Otter arrived on time. Sincere thanks to all who participated in the field programs. Bob Olynyk and Martin Erickson assisted in tabulating data used in the ageing comparisons. Bob Olynyk and Cheryl Campbell assisted in contour map planimetry. Harry Metheringham, Warren and Linda Patterson and Peter Zacharias determined ages of fish. Patricia Laufersweiler and Mirna Jungbauer-Wishart sorted and identified phytoplankters and invertebrates. Dr. J. F. O'Connor edited the report and Barb Bean typed it.

REFERENCES

Abrasov, V. N. 1967. Determination of commercial turnover in natural bodies of water. Problems of Ichthyology. Trans. from Russian by Am. Fish Soc. 9: 482-489.

Carlson, R. E. 1977. A trophic state index for lakes. Limnol. Oceanogr. 22: 361-369.

Hanford, P., G. Bell, and T. Reimchen. 1977. A gillnet fishery considered as an experiment in artificial selection. J. Fish. Res. Board Can. 34: 954-961.

Healey, M. C. 1975. Dynamics of exploited whitefish populations and their management with special reference to the Northwest Territories. J. Fish. Res. Board Can. 32: 427-448.

_____________. 1980. Growth and recruitment in experimentally exploited lake whitefish *(Coregonus clupeaformis)* populations. Can. J. Fish. Aquat. Sci. 37: 255-267.

Lysack, W. 1980. 1979 Lake Winnipeg fish stock assessment program. Man. Dept. Nat. Res. MS Rep. 80-30, 118p.

________________. 1981. 1980 Lake Winnipeg fish stock assessment program. Man. Dept. Nat. Res. MS Rep. 81-20, 67p.

Ricker, W. E. 1975. Computation and interpretation of biological statistics of fish populations. Bull. Fish. Res. Board Can. 119: 382p.

Robson, D. S., and D. G. Chapman. 1961. Catch curves and mortality rates. Trans. Am. Fish. Soc. 90: 181-189.

Ryder, R. A. 1965. A method for estimating the potential fish production of north temperate lakes. Trans. Am. Fish. Soc. 94: 214-218.

Snedecor, G. W., and W. G. Cochran. 1967. Statistical Methods. 6th Ed. Iowa State Univ. Press, Ames, Iowa 593p.

Scott, W. B., and E. J. Crossman. 1973. Freshwater fishes of Canada. Bull.Fish. Res. Board Can. 184: 966p.

APPENDIX A

TEMPERATURE AND OXYGEN PROFILES

Table A1. Temperature (^{o}C) and oxygen (mg. 1^{-1}) profiles of lakes surveyed in 1978.

Depth (m)	Lake																			
	Aswapiswanan		Bearhead		Whitefish		Fairy Rock		Wass		Ankle		Willow		Cuddle		Semple		Max	
	Temp.	O_2	Temp.	O_2	Temp.	O_2	Temp.	O_2	Temp.	O_2	Temp.	O_2	Temp.	O_2	Temp.	O_2	Temp.	O_2	Temp.	O_2
0	16,2	13.3	17.1	8.7	16.2	9.2	16.5	13.2	11.1	13.5	11.5	13.5	14.0	13.7	17.1	8.7	17.6	8.7	16.6	9.6
1	16.2	13.2	17.2	8.5	16.2	9.2	16.5	13.1	11.1	13.6	11.4	13.2	13.9	13.6	17.1	8.7	17.7	8.5	16.7	9.6
2	16.1	12.8	17.2	8.4	16.2	9.1	16.5	13.1	11.1	13.5	11.3	13.2	13.9	13.6	17.1	8.5	17.7	8.5	16.7	9.6
3	16.1	13.0	17.2	8.4	16.2	7.2	16.5	13.2	11.1	13.5	11.3	13.2	13.9	13.7	17.0	8.6	17.7	8.4	16.6	9.7
4	16.1	12.0	17.2	8.4			16.4	13.2	11.1	13.4	11.2	13.2	13.8	13.6	17.0	8.4	17.7	8.4	16.7	9.7
5	16.1	12.3	17.2	7.8			16.4	13.1	11.0	13.3	11.2	13.1	13.6	13.4	17.0	8.5	17.7	8.5	16.6	9.6
6	16.1	12.4					16.3	12.9	10.9	13.3	11.2	13.1	13.6	2.8	17.0	6.7	17.7	8.5	16.7	9.6
7	16.1	11.8					16.2	11.7	10.9	13.2	11.1	13.0					17.7	8.5	16.6	9.6
8	16.1	11.9					15.9	11.4	10.8	13.2	11.1	13.0					17.7	8.4	16.7	9.6
9	16.1	11.9					15.9	10.8	10.8	13.2	11.0	12.8					17.6	8.5	16.5	9.4
10	16.1	12.3					13.7	2.90	10.8	13.2	11.0	12.8					17.5	8.5	16.3	9.3
11	16.1	1.5					9.3	0.40	10.8	13.2	11.0	12.8					17.4	8.4	16.3	9.3
12	16.1						8.0	0.25	10.8	13.2	11.0	12.8					17.4	8.5	16.3	9.2
13	16.1						7.6	0.20	10.8	13.2	11.0	12.6					17.2	8.5	16.2	9.1
14	16.1						7.3	0.15	10.7	13.2	10.9	11.5					17.0	8.3	16.0	7.9
15	16.1						6.9	0.12	10.7	13.2	10.7	10.3					16.8	8.2	14.7	6.4
16							6.9	0.09	10.7	13.2	10.4	9.5					16.7	8.2	14.6	6.1
17							6.9	0.07	10.7	13.2	10.0	6.6					16.7	8.2	14.0	5.6
18							6.9	0.06	10.7	13.2	9.1	3.4					16.7	8.0	13.2	4.8
19											7.4	0.50					11.7	8.0	12.7	4.6
20											7.0	0.30					16.7	7.9	12.5	4.4
21											6.9	0.25					16.7	7.8	12.1	4.1
22											6.9	0.20					16.7	7.5	12.1	4.0
23											6.9	0.15					16.7	7.3	12.0	3.7
24																			12.0	3.5
25																			11.9	3.3

Lake: Barlow

Date: Aug. 23, 1977

Depth (m.)	Station 1 temp.	Station 1 O_2	Station 2 temp.	Station 2 O_2	Station 3 temp.	Station 3 O_2
0	13.0	6.9	13.0	6.9	13.0	6.9
1	13.0	6.9	13.0	6.9	13.0	6.9
2	13.0	6.9	13.0	6.9	13.0	6.9
3	13.0	6.9	13.0	6.9	13.0	6.9
4	13.0	6.9	13.0	6.9	13.0	6.9
5			13.0	6.9	13.0	6.9
6			13.0	6.9		
7			13.0	6.9		
8			13.0	6.9		
9			13.0	6.9		
10			13.0	6.9		
11			13.0	6.9		

Lake: Melvin

Date: Aug. 23, 1977

Station

Depth (m.)	1		2		3	
	temp.	O_2	temp.	O_2	temp.	O_2
0	13.9	9.5	13.5	7.0	13.5	7.0
1	13.9	9.5	13.2	6.9	13.5	7.0
2	13.5	9.0	13.0	6.8	13.2	7.0
3	13.5	9.0	13.0	6.8	13.0	6.9
4	13.0	6.9	13.0	6.8	13.0	6.9
5	13.0	6.9	13.0	6.8	13.0	6.9
6	13.0	6.9	13.0	6.8		
7	13.0	6.9	13.0	6.8		
8	13.0	6.9	13.0	6.8		
9	13.0	6.9	13.0	6.8		
10	13.0	6.9				
11	13.0	6.9				
12	13.0	6.9				
13	13.0	6.9				
14	13.0	6.9				
15	13.0	6.9				

Lake: Enatik I Date: Aug. 23, 1977

Depth (m.)	Station 1 temp.	Station 1 O_2	Station 2 temp.	Station 2 O_2	Station 3 temp.	Station 3 O_2
0	12.5	6.6	12.5	6.6	12.5	6.6
1	12.5	6.6	12.5	6.6	12.5	6.6
2	12.5	6.6	12.5	6.6	12.5	6.6
3	12.5	6.6	12.5	6.6	12.5	6.6
4	12.5	6.6	12.5	6.6	12.5	6.6
5			12.5	6.6	12.5	6.6
6			12.5	6.6	12.5	6.6
7			12.5	6.6		
8			12.5	6.6		

Lake: Enatik II Date: Aug. 23, 1977

Depth (m.)	Station 1 temp.	Station 1 O_2	Station 2 temp.	Station 2 O_2	Station 3 temp.	Station 3 O_2
0	13.0	6.9	13.0	6.9	13.5	7.0
1	13.0	6.9	13.0	6.9	13.5	7.0
2	13.0	6.9	13.0	6.9	13.5	7.0
3	13.0	6.9	13.0	6.9	13.5	7.0
4	13.0	6.9	13.0	6.9	13.5	7.0
5	13.0	6.9	13.0	6.9	13.5	7.0
6	13.0	6.9			13.5	7.0
7	13.0	6.9			13.5	7.0
8	13.0	6.9			13.5	7.0
9	13.0	6.9			13.0	6.9
10					13.0	6.9
11					13.0	6.9
12					13.0	6.9
13					13.0	6.9
14					13.0	6.9

Lake: MacBride Date: Aug. 22, 1977

Station

Depth (m.)	1		2		3	
	temp.	O_2	temp.	O_2	temp.	O_2
0	13.5	7.0	14.0	7.2	13.5	7.0
1	13.5	7.0	14.0	7.2	13.5	7.0
2	13.5	7.0	14.0	7.2	13.5	7.0
3	13.5	7.0	14.0	7.2		
4	13.5	7.0	13.5	7.0		
5	13.5	7.0				

Lake: Magrath

Date: Aug. 22, 1977

Depth (m.)	Station 1 temp.	Station 1 O_2	Station 2 temp.	Station 2 O_2	Station 3 temp.	Station 3 O_2
0	13.5	7.0	13.0	6.8	13.0	6.8
1	13.5	7.0	13.0	6.8	13.0	6.8
2	13.5	7.0	13.0	6.8	13.0	6.8
3	13.5	7.0			13.0	6.8
4	13.5	7.0				
5	13.5	7.0				
6	13.5	7.0				
7	13.5	7.0				
8	13.5	7.0				
9	13.5	7.0				
10	13.5	7.0				
11	13.5	7.0				
12	13.5	7.0				

Lake: Fraser Date: Aug. 22, 1977

Depth (m.)	Station 1		2		3	
	temp.	O_2	temp.	O_2	temp.	O_2
0	13.0	6.8	13.0	6.8	13.0	6.8
1	13.0	6.8	13.0	6.8	13.0	6.8
2	13.0	6.8	13.0	6.8	13.0	6.8
3			13.0	6.8	13.0	6.8
4			13.0	6.8	13.0	6.8

Lake: Pine I

Date: Aug. 22, 1977

Depth (m.)	Station 1 temp.	Station 1 O_2	Station 2 temp.	Station 2 O_2	Station 3 temp.	Station 3 O_2
0	12.0	6.3	12.0	6.3	12.0	6.3
1	12.0	6.3	12.0	6.3	12.0	6.3
2					12.0	6.3
3					12.0	6.3
4					12.0	6.3
5					12.0	6.3
6					12.0	6.3

Lake: McAree   Date: Aug. 19, 1977

Depth (m.)	Station					
	temp.	O_2	temp.	O_2	temp.	O_2
0	14.0	9.0	14.0	6.5	14.0	6.5
1	14.0	9.0	14.0	6.5	14.0	6.5
2	14.0	9.0	14.0	6.5	14.0	6.5
3	13.5	8.5	14.0	6.5	14.0	6.5
4	13.5	8.5	14.0	6.5	14.0	6.5
5	13.5	8.5	14.0	6.5	14.0	6.5
6			14.0	6.5	14.0	6.5
7			14.0	6.5	14.0	6.5
8			14.0	6.5		

Lake: McFadden Date: Aug. 19, 1977

Depth (m.)	Station 1 temp.	Station 1 O_2	Station 2 temp.	Station 2 O_2	Station 3 temp.	Station 3 O_2
0	14.0	9.4	14.0	9.4	14.0	9.4
1	14.0	9.4	14.0	9.4	14.0	9.4
2	13.5	9.0	14.0	9.4	14.0	9.4
3	13.5	9.0	13.5	9.0		
4	13.5	9.0	13.5	9.0		
5	13.5	9.0	13.5	9.0		
6			13.5	9.0		

Lake: Lake X Date: Aug. 18, 1977

Depth (m.)	Station 1		Station 2		Station 3	
	temp.	O_2	temp.	O_2	temp.	O_2
0	14.0	9.4	14.0	9.4	13.5	9.0
1	14.0	9.4	14.0	9.4	13.5	9.0
2	14.0	9.4	14.0	9.4	13.5	9.0
3	14.0	9.4	14.0	9.4	13.5	9.0
4	14.0	9.4	14.0	9.4	13.5	9.0
5	14.0	9.4	14.0	9.4	13.5	9.0
6	13.5	9.0			13.5	9.0
7	13.5	9.0				
8	13.5	9.0				

Lake: Numakoos Date: Aug. 18, 1977

Depth (m.)	Station 1 temp.	Station 1 O_2	Station 2 temp.	Station 2 O_2	Station 3 temp.	Station 3 O_2
0	14.0	9.6	14.0	9.6	14.0	9.5
1	14.0	9.6	14.0	9.6	14.0	9.5
2	14.0	9.6	14.0	9.6	14.0	9.5
3	14.0	9.6	13.5	9.0	13.5	9.0
4	13.5	9.0	13.5	9.0	13.5	9.0
5	13.5	9.0	13.5	9.0	13.5	9.0
6	13.5	9.0	13.5	9.0	13.5	9.0
7	13.5	9.0	13.0	7.0	13.5	9.0
8	13.0	7.0	13.0	7.0	13.5	9.0
9	12.5	6.7	13.0	7.0	13.5	9.0
10	12.5	6.7	13.0	7.0	13.5	9.0
11	12.0	6.5	12.5	6.7		
12	12.0	6.5	12.0	6.5		
13	11.5	6.2	11.5	6.2		
14	10.5	5.8	11.0	6.0		
15	10.0	5.4	10.5	5.8		
16	10.0	5.4	10.0	5.4		
17	10.0	5.4	10.0	5.4		
18	10.0	5.4	10.0	5.4		
19	10.0	5.4	10.0	5.4		
20			10.0	5.4		
21			10.0	5.4		
22			10.0	5.4		
23			10.0	5.4		
24			10.0	5.4		
25			9.5	5.1		
26			9.5	5.1		

Lake: Pine II

Date: Aug. 18, 1977

Depth (m.)	Station 1 temp.	Station 1 O_2	Station 2 temp.	Station 2 O_2	Station 3 temp.	Station 3 O_2
0	13.0	7.0	12.5	6.5	12.5	6.5
1	13.0	7.0	12.5	6.5	12.5	6.5
2	13.0	7.0	12.5	6.5	12.5	6.5
3	13.0	7.0				
4	13.0	7.0				
5	13.0	7.0				

Lake: Unagimau

Date: Aug. 17, 1977

Depth (m.)	Station 1 temp.	Station 1 O_2	Station 2 temp.	Station 2 O_2	Station 3 temp.	Station 3 O_2
0	12.0	6.5	12.0	6.5	12.0	6.5
1	12.0	6.5	12.0	6.5	12.0	6.5
2	12.0	6.5			12.0	6.5
3					12.0	6.5

Lake: Grandmother Date: Aug. 18, 1977

Depth (m.)	1		2		3	
	temp.	O_2	temp.	O_2	temp.	O_2
0	12.0	6.5	12.0	6.5	12.0	6.5
1	12.0	6.5	12.0	6.5	12.0	6.5
2					12.0	6.5

Lake: James

Date: Aug. 17, 1977

Station

Depth (m.)	1 temp.	1 O_2	2 temp.	2 O_2	3 temp.	3 O_2
0	13.0	6.5	12.5	6.7	12.5	6.7
1	13.0	6.5	12.5	6.7	12.5	6.7
2	13.0	6.5	12.5	6.7	12.5	6.7
3	13.0	6.5	12.5	6.7	12.5	6.7
4	13.0	6.5	12.5	6.7	12.5	6.7
5	13.0	6.5	12.5	6.7	12.5	6.7
6	13.0	6.5				
7	13.0	6.5				
8	13.0	6.5				
9	13.0	6.5				

Lake: Hurst Date: Aug. 17, 1977

Depth (m.)	Station 1 temp.	Station 1 O_2	Station 2 temp.	Station 2 O_2	Station 3 temp.	Station 3 O_2
0	11.0	6.0	11.0	6.0	11.0	6.0
1	11.0	6.0	11.0	6.0	11.0	6.0
2	11.0	6.0	11.0	6.0	11.0	6.0

Lake: MacKerracher I Date: Aug. 17, 1977

Depth (m.)	Station 1 temp.	Station 1 O_2	Station 2 temp.	Station 2 O_2	Station 3 temp.	Station 3 O_2
0	12.5	6.7	12.5	6.7	12.5	6.7
1	12.5	6.7	12.5	6.7	12.5	6.7
2	12.5	6.7	12.5	6.7	12.5	6.7
3	12.5	6.7	12.5	6.7	12.5	6.7
4	12.5	6.7	12.5	6.7	12.5	6.7
5	12.5	6.7	12.5	6.7	12.5	6.7
6	12.5	6.7	12.5	6.7	12.5	6.7
7			12.5	6.7		
8			12.5	6.7		
9			12.5	6.7		
10			12.5	6.7		
11			12.5	6.7		
12			12.5	6.7		
13			12.5	6.7		

Lake: MacKerracher II Date: Aug. 16, 1977

Depth (m.)	Station 1 temp.	Station 1 O_2	Station 2 temp.	Station 2 O_2	Station 3 temp.	Station 3 O_2
0	11.5	6.2	13.5	9.0	12.8	6.9
1	13.5	7.0	13.5	9.0	13.0	7.1
2	13.5	7.0	13.5	9.0	13.0	7.1
3			13.5	9.0	13.0	7.1
4			13.5	9.0	13.0	7.1
5			13.3	8.0	13.1	7.5
6			13.3	8.0	13.1	7.5
7			13.0	7.0	13.3	8.0
8			13.0	7.0	13.3	8.0
9			12.5	6.7	13.3	8.0
10			12.0	6.5	13.3	8.0
11			12.0	6.5		
12			12.0	6.5		
13			11.5	6.2		
14			11.5	6.2		
15			11.5	6.2		
16			11.3	6.0		
17			11.3	6.0		
18			11.0	6.0		
19			11.0	6.0		
20			10.8	5.8		
21			10.8	5.8		
22			10.5	5.6		
23			10.5	5.6		
24			10.5	5.6		
25			10.0	5.4		
26			10.0	5.4		

Lake: Denison Date: Aug. 16, 1977

	Station					
Depth (m.)	1 temp.	1 O_2	2 temp.	2 O_2	3 temp.	3 O_2
0	12.2	6.5	12.5	6.7	12.5	6.7
1	12.2	6.6	12.5	6.7	12.5	6.7
2	12.5	6.6	12.5	6.7	12.7	6.8
3	12.5	6.6	12.5	6.7	12.7	6.8
4	12.7	6.7	12.5	6.7	12.7	6.8
5	12.7	6.7	12.5	6.7	12.7	6.8
6					12.8	6.9
7					12.8	6.9
8					12.8	6.9
9					12.8	6.9
10					12.8	6.9

Lake: MacPherson Date: Aug. 16, 1977

Depth (m.)	1		2		3	
	temp.	O_2	temp.	O_2	temp.	O_2
0	12.5	6.7	12.8	6.9	12.5	6.7
1	12.5	6.7	12.8	6.9	12.5	6.7
2	12.7	6.8	12.8	6.9	12.5	6.7
3	12.7	6.8	12.8	6.9	12.5	6.7
4			12.8	6.9		

Station

APPENDIX B

LIMNOLOGICAL DATA

Table B1. Color and turbidity in surveyed lakes.

Lake	Station	Color (meter units)	Turbidity (F.T.U.)
James	1	20.0	1.2
	2	30.0	1.1
	3	5.0	2.9
Hurst	1	5.0	2.7
	2	10.0	1.9
	3	5.0	2.1
Unagimau	1	40.0	1.9
	2	20.0	1.2
	3	20.0	0.45
MacKerracher I	1	5.0	15.0
	2	5.0	10.0
	3	5.0	1.5
MacKerracher II	1	10.0	1.2
	2	10.0	1.4
	3	10.0	1.8
Pine II	1	30.0	2.4
	2	30.0	3.6
	3	30.0	1.6
Numakoos	1	5.0	0.9
	2	5.0	1.1
	3	15.0	2.8
Lake X	1	10.0	1.3
	2	5.0	1.4
	3	10.0	1.3
Grandmother	1	45.0	3.6
	2	50.0	2.8
	3	50.0	3.2
Barlow	1	15.0	2.0
	2	15.0	1.9
	3	15.0	1.9
Pine I	1	30.0	2.5
	2	20.0	1.5
	3	20.0	2.0
Fraser	1	15.0	2.3
	2	15.0	2.3
	3	10.0	2.4
Enatik I	1	30.0	5.0
	2	40.0	3.0
	3	30.0	2.9

Enatik II	1	10.0	1.9
	2	10.0	1.8
	3	5.0	1.5
Melvin	1	40.0	1.4
	2	50.0	1.3
	3	40.0	1.9
McAree	1	30.0	1.6
	2	30.0	2.0
	3	30.0	2.0
MacBride	1	20.0	2.0
	2	40.0	2.5
	3	50.0	2.5
Magrath	1	30.0	2.5
	2	30.0	2.5
	3	20.0	2.5
McFadden	1	50.0	2.0
	2	40.0	3.0
	3	50.0	3.0
Denison	1	10.0	2.0
	2	10.0	1.0
	3	10.0	1.0
MacPherson	1	15.0	1.4
	2	15.0	1.3
	3	15.0	1.5
Whitefish	1	<5	10.0
	2	<5	7.0
	3	<5	9.0
Bearhead	1	10	6
	2	25	5.5
	3	20	4
Cuddle	1	15	4
	2	15	4
	3	20	8
Semple	1	5	5.5
	2	5	4
	3	10	2.5
Max	1	<5	6
	2	5	7
	3	5	5

Aswapiswanan	1	5	5
	2	5	2.5
	3	15	5
Willow	1	5	3
	2	5	3
	3	5	4
Wass	1	15	9
	2	15	8
	3	15	6
Ankle	1	15	3
	2	15	2.5
	3	15	2.5

Table B2. Concentrations of some elements and ions in surveyed lakes.

Lake	Station	Concentrations (mg l^{-1})							
		Ca	Mg	$CaCO_3$	Fe	K	Na	Cl (Sol.)	SO_4(Sol.)
James	1	10.0	5.0	35.0	0.05	2.0	10.0	2.0	5.0
	2	10.0	5.0	35.0	0.05	2.0	10.0	2.0	5.0
	3	7.5	5.0	29.0	0.02	2.0	10.0	2.0	5.0
Hurst	1	15.0	5.0	48.0	0.10	2.0	10.0	2.0	5.0
	2	15.0	5.0	48.0	0.05	2.0	10.0	2.0	5.0
	3	15.0	5.0	48.0	0.05	2.0	10.0	2.0	5.0
Unagimau	1	10.0	5.0	35.3	0.14	2.0	10.0	2.0	5.0
	2	10.0	5.0	35.3	0.05	2.0	10.0	2.0	5.0
	3	10.0	5.0	35.3	0.05	2.0	10.0	2.0	5.0
MacKerracher I	1	15.0	5.0	48.0	0.02	2.0	10.0	2.0	5.0
	2	15.0	5.0	48.0	0.02	2.0	10.0	2.0	5.0
	3	15.0	5.0	48.0	0.02	2.0	10.0	2.0	5.0
MacKerracher II	1	15.0	5.0	47.8	0.10	2.0	10.0	2.0	5.0
	2	15.0	5.0	47.8	0.07	2.0	10.0	2.0	5.0
	3	15.0	5.0	47.8	0.07	3.0	10.0	2.0	5.0
Pine II	1	15.0	5.0	48.0	0.14	2.0	10.0	2.0	5.0
	2	15.0	5.0	48.0	0.10	2.0	10.0	2.0	5.0
	3	15.0	5.0	48.0	0.10	2.0	10.0	2.0	5.0
Numakoos	1	20.0	5.0	60.0	0.02	2.0	10.0	2.0	5.0
	2	20.0	5.0	60.0	0.02	2.0	10.0	2.0	5.0
	3	20.0	5.0	60.0	0.02	2.0	10.0	2.0	5.0
Lake X	1	22.5	5.0	67.0	0.02	2.0	10.0	2.0	5.0
	2	22.5	5.0	67.0	0.02	2.0	10.0	2.0	5.0
	3	22.5	5.0	67.0	0.02	2.0	10.0	2.0	5.0
Grandmother	1	17.5	5.0	54.0	0.21	2.0	10.0	2.0	5.0
	2	15.0	5.0	48.0	0.10	2.0	10.0	2.0	5.0
	3	20.0	5.0	60.0	0.21	2.0	10.0	2.0	5.0
Barlow	1	15.0	10.0	78.5	0.10	2.0	10.0	2.0	5.0
	2	15.0	5.0	47.8	0.10	2.0	10.0	2.0	5.0
	3	15.0	5.0	47.8	0.10	2.0	10.0	2.0	5.0
Pine I	1	15.0	5.0	47.8	0.13	2.0	10.0	2.0	10.0
	2	15.0	5.0	47.8	0.13	2.0	10.0	2.0	5.0
	3	15.0	5.0	47.8	0.13	2.0	10.0	2.0	5.0
Fraser	1	12.5	5.0	41.3	0.10	2.0	10.0	2.0	5.0
	2	12.5	5.0	41.3	0.10	2.0	10.0	2.0	5.0
	3	12.5	5.0	41.3	0.10	2.0	10.0	2.0	5.0

Enatik I	1	10.0	5.0	35.3	0.22	2.0	10.0	2.0	5.0
	2	10.0	5.0	35.3	0.19	2.0	10.0	2.0	5.0
	3	12.5	5.0	41.3	0.19	2.0	10.0	2.0	5.0
Enatik II	1	15.0	5.0	47.8	0.05	2.0	10.0	2.0	5.0
	2	15.0	5.0	47.8	0.05	2.0	10.0	2.0	10.0
	3	15.0	5.0	47.8	0.05	2.0	10.0	2.0	10.0
Melvin	1	7.5	5.0	29.1	0.19	2.0	10.0	2.0	5.0
	2	7.5	5.0	29.1	0.13	2.0	10.0	2.0	5.0
	3	5.0	5.0	22.8	0.22	2.0	10.0	2.0	10.0
McAree	1	10.0	5.0	35.3	0.10	2.0	10.0	2.0	10.0
	2	10.0	5.0	35.3	0.05	2.0	10.0	2.0	5.0
	3	10.0	5.0	35.3	0.05	2.0	10.0	2.0	10.0
MacBride	1	10.0	5.0	35.3	0.19	2.0	10.0	2.0	5.0
	2	10.0	5.0	35.3	0.19	2.0	10.0	2.0	10.0
	3	10.0	5.0	35.3	0.13	2.0	10.0	2.0	5.0
Magrath	1	10.0	5.0	35.3	0.13	2.0	10.0	2.0	5.0
	2	10.0	5.0	35.3	0.13	2.0	10.0	2.0	5.0
	3	10.0	5.0	35.3	0.13	2.0	10.0	2.0	5.0
McFadden	1	10.0	5.0	35.3	0.22	2.0	10.0	2.0	5.0
	2	10.0	5.0	35.3	0.26	2.0	10.0	2.0	10.0
	3	15.0	5.0	47.8	0.26	2.0	10.0	2.0	5.0
Denison	1	15.0	5.0	47.8	0.07	2.0	10.0	2.0	5.0
	2	15.0	5.0	47.8	0.10	2.0	10.0	2.0	5.0
	3	15.0	5.0	47.8	0.07	2.0	10.0	2.0	5.0
MacPherson	1	15.0	5.0	47.8	0.15	2.0	10.0	2.0	5.0
	2	15.0	5.0	47.8	0.15	2.0	10.0	2.0	5.0
	3	15.0	5.0	47.8	0.15	2.0	10.0	2.0	5.0
Whitefish	1	13	<5	41	-	<2	<10	<2	<5
	2	19	<5	58	-	<2	<10	<2	<5
	3	30	6	98	-	<2	<10	<2	<5
Bearhead	1	13	<5	41	-	<2	<10	<2	<5
	2	10	<5	35	-	<2	<10	<2	<5
	3	10	<5	35	-	<2	<10	<2	<5
Cuddle	1	10	<5	35	-	<2	<10	<2	5
	2	19	<5	58	-	<2	<10	<2	<5
	3	5	<5	23	-	<2	<10	<2	5
Semple	1	11	6	51	-	<2	<10	<2	10
	2	9	<5	33	-	<2	<10	<2	10
	3	9	<5	33	-	<2	<10	<2	5

Max	1	9	<5	33	-	<2	<10	<2	5
	2	9	<5	33	0	<2	<10	<2	5
	3	14	<5	45	-	<2	<10	<2	5
Aswapiswanan	1	14	<5	45	-	<2	<10	<2	5
	2	11	<5	38	-	<2	<10	<2	10
	3	11	<5	38	-	<2	<10	<2	10
Fairy Rock	1								
	2								
	3								
Willow	1	14	<5	45	-	<2	<10	<2	5
	2	9	<5	33	-	<2	<10	<2	5
	3	9	<5	33	-	<2	<10	<2	5
Wass	1	9	<5	33	-	<2	<10	<2	5
	2	14	<5	45	-	<2	<10	<2	<5
	3	6	<5	25	-	<2	<10	<2	<5
Ankle	1	6	<5	25	-	<2	<10	<2	5
	2	14	<5	45	-	<2	<10	<2	5
	3	9	<5	33	-	<2	<10	<2	5

Table B3. Carbon, nitrogen and phosphorus concentrations in surveyed lakes.

Lake	Station	Carbon (mg l^{-1})		Nitrogen (mg l^{-1})	Total P(mg l^{-1})
		T.O.C.	T.I.C.	NO_2 - NO_3 (Diss) - N	
James	1	12.5	2.5	0.01	0.02
	2	13.0	2.5	0.10	0.02
	3	10.0	4.5	0.01	0.02
Hurst	1	15.0	1.5	0.01	0.02
	2	14.5	7.5	0.01	0.03
	3	13.5	7.5	0.01	0.02
Unagimau	1	15.5	3.5	0.01	0.02
	2	13.0	2.5	0.01	0.02
	3	13.5	2.5	0.01	0.02
MacKerracher I	1	10.0	9.0	0.01	0.02
	2	10.0	9.0	0.01	0.02
	3	10.0	9.0	0.01	0.02
MacKerracher II	1	20.0	9.5	0.01	0.02
	2	19.0	9.5	0.03	0.04
	3	19.0	9.5	0.01	0.03
Pine II	1	20.0	6.5	0.01	0.02
	2	17.5	6.5	0.01	0.02
	3	17.0	6.5	0.01	0.02
Numakoos	1	9.5	9.5	0.01	0.02
	2	10.0	10.5	0.01	0.02
	3	13.5	9.0	0.01	0.02
Lake X	1	12.0	11.5	0.01	0.02
	2	11.5	11.5	0.02	0.02
	3	11.5	11.5	0.01	0.02
Grandmother	1	22.5	6.5	0.01	0.03
	2	23.0	6.0	0.01	0.03
	3	24.0	6.0	0.08	0.03
Barlow	1	17.0	9.5	0.01	0.04
	2	18.5	10.0	0.01	0.03
	3	15.0	10.5	0.01	0.03
Pine I	1	18.0	10.0	0.01	0.04
	2	18.5	9.0	0.01	0.04
	3	17.5	9.5	0.26	0.04
Fraser	1	13.5	8.5	0.01	0.02
	2	12.5	8.0	0.01	0.02
	3	12.0	8.0	0.01	0.02

Enatik I	1	14.5	6.0	0.01	0.18
	2	15.5	5.5	0.01	0.02
	3	15.5	5.5	0.01	0.02
Enatik II	1	11.5	8.5	0.01	0.02
	2	11.5	9.0	0.01	0.02
	3	14.5	8.5	0.01	0.03
Melvin	1	17.5	2.0	0.01	0.02
	2	16.0	2.5	0.01	0.02
	3	16.0	2.5	0.01	0.02
McAree	1	14.0	7.5	0.01	0.02
	2	15.0	7.0	0.01	0.02
	3	15.0	6.5	0.01	0.02
MacBride	1	17.5	6.0	0.01	0.02
	2	17.0	6.0	0.01	0.02
	3	17.5	6.0	0.01	0.02
Magrath	1	19.0	8.5	0.01	0.02
	2	18.5	8.5	0.01	0.03
	3	18.5	8.5	0.01	0.03
McFadden	1	20.0	7.0	0.02	0.03
	2	18.5	7.0	0.05	0.02
	3	18.0	6.5	0.01	0.03
Dension	1	17.5	8.5	0.01	0.04
	2	18.0	8.5	0.01	0.02
	3	19.0	8.5	0.01	0.02
MacPherson	1	24.5	10.0	0.01	0.02
	2	21.5	10.0	0.01	0.08
	3	21.5	9.5	0.01	0.07
Whitefish	1	7.0	-	<.01	<.02
	2	5.0	-	.13	<.02
	3	6.5	-	.20	.02
Bearhead	1	11	-	<.01	.03
	2	16	-	.01	.03
	3	15	-	.4	.05
Cuddle	1	13	-	.02	.02
	2	14	-	.05	.02
	3	-	-	.35	.02
Semple	1	-	-	.07	.03
	2	-	-	.1	.02
	3	-	-	.02	.02
Max	1	-	-	.33	<.02
	2	-	-	.11	<.02
	3	-	-	.41	.02

Aswapiswanan	1	-	-	.05	.02
	2	-	-	.03	.02
	3	-	-	.02	<.02
Willow	1	-	-	.05	.03
	2	-	-	.59	.09
	3	-	-	1.1	.12
Wass	1	-	-	.01	.04
	2	-	-	.01	.02
	3	-	-	.01	.03
Ankle	1	-	-	.01	<.02
	2	-	-	.02	.02
	3	-	-	.01	.03

APPENDIX C

PLANKTONIC AND BENTHIC SPECIES

BARLOW LAKE

August 23, 1977

CYANOPHYTA (Blue-Green Algae)

Anabaena
Aphanothece
Gloeotrichia
Microcystis aeruginosa
M. (formerly *Aphanocapsa* spp)
M. wesenbergii
Oscillatoria

CHLOROPHYTA (Green Algae)

Dictyosphaerium pulchellum
Pediastrum boryanum
P. duplex var. *clathrum*
P. d. var. *gracilimum*

Desmidiaceae

Staurastrum
Staurodesmus
cf *Teilingia*
Xanthidium

CHRYSOPHYTA (Yellow-Brown Algae)
Bacillariophyceae - Preliminary Analysis

Achnanthes
Asterionella
Cyclotella
Cymatopleura
Cymbella
Fragilaria
Gyrosigma
Melosira
Navicula
Nitzschia
Rhizosolenia
Stephanodiscus
Surirella
Synedra
Tabellaria

PYRRHOPHYTA (Dinoflagellates)

Ceratium hirundinella

ROTIFERA

Asplanchna
Brachionus
Kellicottia
Keratella
Trichocerca

ARTHROPODA
- Crustacea
  - Branchiopoda
    - Cladocera
      - *Bosmina*
      - *Chydoras*
      - *Daphnia*
      - *Diaphanosoma*
      - *Leptodora*
  - Copepoda
    - *Cyclops*
    - *Diaptomus*
    - *Epischura*
    - *Mesocyclops*
    - *Tropocyclops*
- Insecta
  - Diptera
    - Chaoboridae
      - *Chaoborus*
    - Chironomidae (head capsules)

DENISON LAKE

August 16, 1977

CYANOPHYTA (Blue-Green Algae)

- *Anabaena*
- *Aphanizomenon*
- *Chroococcus*
- *Gomphosphaeria lacustris*
- *Lyngbya*
- *Merismopedia elegans*
- *Microcystis aeruginosa*
- *M.* (formerly *Aphanocapsa* spp)
- *M. wesenbergii*
- *Oscillatoria*

CHLOROPHYTA (Green Algae)

- *Ankistrodesmus westii* (cf *gracile*)
- *Botryococcus protuberans*
- *Dictyosphaerium pulchellum*
- *Eudorina*
- *Gloeocystis*
- *Gloeotila*
- *Mougeotia*
- *Paulschulzia*
- *Pediastrum duplex* var. *clathratum*
- *P. duplex* var. *typicum* fo. *reticulatum*
- *P. kawraiska?*
- *Scenedesmus*
- *Ulothrix zonata*

Desmidiaceae

- *Cosmarium*
- *Spondylosium*

CHRYSOPHYTA (Yellow-Brown Algae)

- *Dinobryon divergens*
- *D. sertularia*
- *D. sociale*

Bacillariophyceae - Preliminary Analysis

- *Achnanthes*
- *Amphora*
- *Asterionella*
- *Campylodiscus*
- *Cocconeis*
- *Cyclotella*
- *Cymbella*
- *Diatoma*
- *Diploneis*
- *Epithemia*
- *Fragilaria*
- *Gyrosigma*
- *Melosira*
- *Navicula*
- *Nitzschia*
- *Opephora*

Rhizosolenia
Stephanodiscus
Surirella
Synedra
Tabellaria

PYRRHOPHYTA (Dinoflagellates)

Ceratium hirundinella

ROTIFERA

Asplanchna
Kellicottia
Keratella
Trichocerca

ARTHROPODA
- Crustacea
  - Branchipoda
    - Cladocera

Bosmina
Chydoras
Daphnia
Diaphanosoma
Leptodora kindtii

- Copepoda

Cyclops
Diaptomus
Tropocyclops (?)

- Insecta
  - Diptera
    - Chironomidae (head capsules)

ENATIK I LAKE

August 23, 1977

CYANOPHYTA (Blue-Green Algae)

- *Anabaena*
- *Aphanothece*
- *Gloeotrichia*
- *Lyngbya*
- *Gomphosphaeria lacustris*
- *Merismopedia*
- *Microcystis* (formerly *Aphanocapsa* spp)
- *M. wesenbergii*
- *Oscillatoria*

CHLOROPHYTA (Green Algae)

- *Carteria?*
- *Mougeotia*
- *Pediastrum boryanum*
- *P. duplex* var. *clathrum*
- *Planctonema lauterbornii*
- *Ulothrix (zonata?)*

Desmidiaceae

- *Arthrodesmus* cf *octocornis*
- *Closterium*
- *Spondylosium*
- *Staurastrum*
- *Teilingia*

CHRYSOPHYTA (Yellow-Brown Algae)

- *Dinobryon bavaricum*
- *D. divergens*
- *D. sertularia*

Bacillariophyceae - Preliminary Analysis

- *Asterionella*
- *Cocconeis*
- *Cyclotella*
- *Cymbella*
- *Fragilaria*
- *Gyrosigma*
- *Melosira*
- *Navicula*
- *Nitzschia*
- *Rhopalodia?*
- *Stephanodiscus*
- *Surirella*
- *Synedra*
- *Tabellaria*

PYRRHOPHYTA (Dinoflagellates)

- *Ceratium hirundinella*

- ROTIFERA
  - *Kellicottia*
  - *Trichocerca*
- ARTHROPODA
  - Crustacea
    - Branchiopoda
      - Cladocera
        - *Bosmina*
        - *Chydoras*
        - ***Daphnia***
        - *Diaphanosoma*
        - *Holopedium gibberum*
        - *Polyphemus*
    - Copepoda
      - *Cyclops*
      - *Diaptomus*
      - *Epischura lacustris*

ENATIK II LAKE

August 23, 1977

CYANOPHYTA (Blue-Green Algae)

Anabaena
Chroococcus
Coelosphaerium?
Gomphosphaeria lacustris
Lyngbya
Microcystis aeruginosa
M. (formerly *Aphanocapsa* spp)
M. wesenbergii
Oscillatoria

CHLOROPHYTA (Green-Algae)

Mougeotia
Pediastrum biradiatum
P. boryanum
Planctonema lauterbornii
Ulothrix

Desmidiaceae

Arthrodesmus cf *octocornis*
Cosmarium
Pleurotaenium
Staurastrum
Staurodesmus megacanthus
Teilingia

CHRYSOPHYTA (Yellow-Brown Algae)

Dinobryon bavaricum

Bacillariophyceae - Preliminary Analysis

Achnanthes
Asterionella
Cocconeis
Cyclotella
Diploneis
Epithemia
Fragilaria
Gyrosigma
Melosira
Navicula
Rhizosolenia
Rhopalodia?
Stephanodiscus
Surirella
Synedra
Tabellaria

ROTIFERA

Asplanchna
Kellicottia
Keratella
Ploesoma
Polyarthra
Trichocerca

ARTHROPODA
  Crustacea
   Branchiopoda
    Cladocera
      Bosmina
      Chydorus
      Daphnia
      Diaphanosoma
      Holopedium
      Leptodora
   Copepoda
      Cyclops
      Diaptomus
      Epischura

FRASER LAKE

August 22, 1977

CYANOPHYTA (Blue-Green Algae)

Anabaena
Aphanizomenon
Aphanothece
Cyanocystis (Dermocarpa) rostrata
 &/or *Stichosiphon*
Gloeocapsa
Gomphosphaeria aponina
Lyngbya
Microcystis aeruginosa
M. (formerly *Aphanocapsa* spp)
Merismopedia
Nostoc
Oscillatoria

CHLOROPHYTA (Green Algae)

Dictyosphaerium pulchellum
Gloeocystis
Mougeotia
Paulschulzia
Pediastrum boryanum
P. duplex var. *typicum* fo. *reticulatum*
Ulothrix

Desmidiaceae

Arthrodesmus cf *octocornis*
Closterium
Teilingia

CHRYSOPHYTA (Yellow-Brown Algae)

Dinobryon bavaricum
D. divergens
D. sertularia
D. sociale var. *americanum*
D. tabellariae
Mallomonas?

Bacillariophyceae - Preliminary Analysis

Achnanthes
Amphora
Asterionella
Campylodiscus
Cocconeis
Cyclotella
Cymbella
Diatoma?
Epithemia
Fragilaria
Melosira
Navicula
Nitzschia
Pinnularia
Rhizosolenia
Stauroneis

Stephanodiscus
Surirella
Synedra
Tabellaria

PYRRHOPHYTA
Ceratium hirundinella

ROTIFERA
Asplanchna
Kellicottia
Keratella
Polyarthra
Trichocerca

ARTHROPODA
Crustacea
Branchiopoda
Cladocera
Bosmina longirostris
Ceriodaphnia quadrangula
Chydoras
Daphnia
Diaphanosoma
Eurycercus lamellatus
Holopedium gibberum
Leptodora kindtii
Simocephalus serrulatus
Copepoda
Cyclops
Diaptomus
Epischura
Mesocyclops
Tropocyclops
Malacostraca
Amphipoda
Hyalella azteca

GRANDMOTHER LAKE

August 18, 1977

CYANOPHYTA (Blue-Green Algae)

- *Anabaena*
- *Aphanizomenon*
- *Aphanothece*
- *Chroococcus limneticum*
- *Chroococcopsis?*
- *Coelosphaerium*
- *Cyanocystis (Dermocarpa) rostrata* and/or *Stichosiphon*
- *Gomphosphaeria aponina*
- *G. lacustris*
- *Lyngbya*
- *Merismopedia elegans*
- *M. punctata*
- *Microcoleus?*
- *Microcystis aeruginosa*
- *M.* (formerly *Aphanocapsa* spp)
- *M. wesenbergii*
- *Oscillatoria*
- *Rivularia*
- *Synechocystis?*

CHLOROPHYTA (Green Algae)

- *Actinastrum?*
- *Botryococcus braunii*
- *B. protuberans*
- *Chlorogonium* or *Chlamydomonas*
- *Dictyosphaerium ehrenbergii*
- *D. pulchellum*
- *Coelastrum reticulatum*
- *Crucigenia quadrata*
- *Elakatothrix genevensis*
- *Gloeocystis*
- *Hyaloraphidium?*
- *Kirchneriella*
- *Mougeotia*
- *Oocystis*
- *Paulschulzia*
- *Pediastrum boryanum*
- *P. boryanum* var. *longicorne*
- *P. duplex*
- *P. tetras* var. *tetraedron*
- *Radiococcus*
- *Scenedesmus*
- *Tetraedron limneticum*
- *T.* sp.

Desmidiaceae	
	Closterium
	Cosmarium
	Staurastrum
CHRYSOPHYTA (Yellow-Brown Algae)	
	Dinobryon sociale var. *americanum*
Bacillariophyceae - Preliminary Analysis	
	Achnanthes
	Amphora
	Asterionella
	Cocconeis
	Coscinodiscus
	Cyclotella
	Cymbella
	Fragilaria
	Gyrosigma
	Melosira
	Navicula
	Nitzschia
	Pinnularia
	Rhopalodia
	Stauroneis
	Stephanodiscus
	Surirella
	Synedra
	Tabellaria
PYRRHOPHYTA (Dinoflagellates)	
	Ceratium hirundinella
	Dinococcus - epiphytic on *Lyngbya*
ROTIFERA	
	Kellicottia
	Keratella
ARTHROPODA	
Crustacea	
Branchiopoda	
Cladocera	
	Alona
	Bosmina longirostris
	Daphnia pulicaria
Copepoda	
	Cyclops
	Diaptomus
	Epischura lacustris
	Tropocyclops

HURST LAKE

August 17, 1977

CYANOPHYTA (Blue-Green Algae)

Anabaena
Aphanothece
Calothrix?
Chroococcus
Eucapsis
Gloeocapsa
Gloeothece
Gloeotrichia
Gomphosphaeria aponina
G. lacustris
Lyngbya
Microcystis aeruginosa
M. (formerly *Aphanocapsa* spp)
M. wesenbergii
Pseudanabaena mucicola
Stichosiphon

CHLOROPHYTA (Green Algae)

Ankistrodesmus fusiformis
A. (formerly *Selenastrum*) *bibrairum?*
Botryococcus protuberans
Chlorella?
Cladophora (Aegagropila)?
Crucigenia quadrata?
C. rectangularis
Genicularia elegans
Kirchneriella
Oocystis
Pediastrum boryanum
P. kawraiska
P. tetras var. *tetraedron*
Salpingoeca?
Scenedesmus
Ulothrix (zonata)?

Desmidiaceae

Arthrodesmus cf *octocornis*
Cosmarium
Staurastrum
Staurodesmus megacanthus
Spondylosium

CHRYSOPHYTA (Yellow-Brown Algae)

Chrysosphaerella multispina
Dinobryon bavaricum
D. divergens (cf var. *Schauinslandii*)
Mallomonas?

- Bacillariophyceae - Preliminary Analysis
  - *Asterionella*
  - *Cocconeis?*
  - *Cymbella*
  - *Fragilaria*
  - *Navicula*
  - *Nitzschia*
  - *Pinnularia*
  - *Stauroneis*
  - *Surirella*
  - *Synedra*
  - *Tabellaria*

- PROTOZOA
  - Cileatea
    - *Vorticella*

- ROTIFERA
  - *Kellicottia*
  - *Keratella*
  - *Polyarthra*
  - *Trichocerca*

- ARTHROPODA
  - Crustacea
    - Branchiopoda
      - Cladocera
        - *Bosmina*
        - *Ceriodaphnia*
        - *Chydoras*
        - *Daphnia*
    - Copepoda
      - *Cyclops*
      - *Diaptomus*
      - *Epischura*
    - Malacostraca
      - Amphipoda
        - *Hyalella azteca*

JAMES LAKE

August 17, 1977

CYANOPHYTA (Blue-Green Algae)

Anabaena
Aphanothece
Chroococcus
Gloeocapsa
Gomphosphaeria lacustris
Lyngbya
Merismopedia
Microcystis aeruginosa
M. (formerly *Aphanocapsa* spp)
M. wesenbergii
Synechococcus
Synechocystis?

CHLOROPHYTA (Green Algae)

Botryococcus (braunii?)
Botryosphaera sudetica
Elakatothrix?
Gloeocystis
Kirchneriella
Mougeotia?
Pediastrum boryanum
P. duplex
P. kawraiska
P. simplex
P. tetras
Paulschulzia
Polyblepharides?
Pyramimonas?
Scenedesmus
Spirogyra
Tetraedron minimum?

Desmidiaceae

Closterium
Cosmarium
Desmidium
Docidium
Spondylosium?
Staurastrum
Xanthidium

CHRYSOPHYTA (Yellow-Brown Algae)

Dinobryon bavaricum

Bacillariophyceae - Preliminary Analysis

Achnanthes
Asterionella
Cocconeis
Cyclotella
Cymbella
Epithemia
Fragilaria
Melosira
Navicula

- *Nitzschia*
- *Pinnularia*
- *Stauroneis*
- *Surirella*
- *Synedra*
- *Tabellaria*

PYRRHOPHYTA (Dinoflagellates)

- *Ceratium hirundinella*

ROTIFERA

- *Asplanchna*
- *Kellicottia*
- *Keratella*
- *Ploesoma*
- *Polyarthra*
- *Trichocerca*

ARTHROPODA
- Branchiopoda
  - Cladocera
    - *Bosmina*
    - *Ceriodaphnia*
    - *Chydorus*
    - *Daphnia*
    - *Diaphanosoma*
    - *Holopedium gibberum*
    - *Leptodora*
    - *Polyphemus*
- Copepoda
  - *Cyclops*
  - *Diaptomus*
  - *Epischura lacustris*
  - *Tropocyclops*

MACBRIDE LAKE

August 22, 1977

CYANOPHYTA (Blue-Green Algae)

Anabaena
Aphanizomenon
Chroococcus
Gloeothece
Gomphosphaeria lacustris
G. naegliana
Lyngbya
Merismopedia
Microcystis aeruginosa
M. (formerly *Aphanocapsa* spp)
Oscillatoria

CHLOROPHYTA (Green Algae)

Dictyosphaerium
Geminella
Mougeotia
Pediastrum duplex
P. kawraiska?
P. lauterbornii
Scenedesmus

Desmidiaceae

Bambusina
Closterium ceratium
Cosmarium
Staurastrum

CHRYSOPHYTA (Yellow-Brown Algae)

Dinobryon bavaricum
D. divergens
D. sociale
Mallomonas?

Bacillariophyceae - Preliminary Analysis

Asterionella
Cymbella
Diatoma?
Diploneis
Epithemia
Fragilaria
Gyrosigma
Melosira
Navicula
Nitzschia
Pinnularia
Stephanodiscus
Surirella
Synedra
Tabellaria

PYRRHOPHYTA (Dinoflagellates)

- *Ceratium hirundinella*

ROTIFERA

- *Filinia*
- *Kellicottia*
- *Keratella*
- *Polyarthra*
- *Trichocerca*

ARTHROPODA
- Crustacea
  - Branchiopoda
    - Cladocera
      - *Bosmina*
      - *Ceriodaphnia*
      - *Chydoras*
      - *Daphnia*
      - *Diaphanosoma*
      - *Eurycercus*
      - *Leptadora kindtii*
      - *Sida crystallina*
  - Copepoda
    - *Cyclops*
    - *Diaptomus*
    - *Epischura lacustris*
    - *Tropocyclops*

MACKERRACHER I LAKE

August 16, 1977

CYANOPHYTA (Blue-Green Algae)

Anabaena
Aphanizomenon
Aphanothece
Chroococcus
Gloeotrichia
Gomphosphaeria aponina
G. lacustris
Lyngbya
Microcystis aeruginosa
M. (formerly *Aphanocapsa* spp)
M. wesenbergii
Oscillatoria

CHLOROPHYTA (Green Algae)

Binucleara?
Crucigenia rectangularis
Dictyosphaerium pulchellum
Pediastrum biradiatum
P. duplex var. *typicum*
P. kawraiska
P. tetras
P. tetras var. *tetraedron*
Scenedesmus
Sphaerocystis
Spirogyra

Desmidiaceae

Arthrodesmus cf *octocornis*
Staurastrum (2 spp)

CHRYSOPHYTA (Yellow-Brown Algae)

Dinobryon bavaricum
D. divergens
D. sociale
D. sociale var. *stipitatum*

Bacillariophyceae - Preliminary Analysis

Achnanthes
Asterionella
Cocconeis
Cyclotella
Cymbella?
Epithemia
Fragilaria
Gyrosigma
Melosira
Navicula
Nitzschia
Stephanodiscus
Surirella
Synedra
Tabellaria

PYRRHOPHYTA (Dinoflagellates)

- *Ceratium hirundinella*
- *Gymnodinium*

ROTIFERA

- *Asplanchna*
- *Keratella*
- *Kellicottia*
- *Ploesoma*
- *Polyarthra*
- *Trichocerca*

ARTHROPODA
- Crustacea
  - Branchiopoda
    - Cladocera
      - *Bosmina*
      - *Daphnia*
      - *Holopedium*
      - *Leptodora kindtii*
      - *Sida crystallina*
  - Copepoda
    - *Cyclops*
    - *Diaptomus*

MACKERRACHER II LAKE

August 16, 1977

CYANOPHYTA (Blue-Green Algae)

- *Anabaena*
- *Aphanothece*
- *Aphanizomenon*
- *Chroococcus*
- *Gloeotrichia*
- *Gomphosphaeria lacustris*
- *G. naegliana*
- *Lyngbya*
- *Microcystis aeruginosa*
- *M.* (formerly *Aphanocapsa* spp)
- *M. wesenbergii*
- *Oscillatoria*

CHLOROPHYTA (Green Algae)

- *Ankistrodesmus bibrainum* (or *gracile* with one pyrenoid)
- *Dictyosphaerium pulchellum*
- *Gloeocystis*
- *Kirchneriella*
- *Paulschulzia*
- *Pediastrum biradiatum*
- *P. duplex*
- *P. kawraiska*
- *Planctonema lauterbornii*
- *Scenedesmus*
- *Sphaerocystis*
- *Ulothrix?*
- *Westella?*

Desmidiaceae

- *Arthrodesmus* cf *octocornis*
- *Cosmarium*
- *Spondylosium*
- *Staurastrum*

CHRYSOPHYTA (Yellow-Brown Algae)

Bacillariophyceae - Preliminary Analysis

- *Achnanthes*
- *Asterionella*
- *Cocconeis*
- *Cyclotella*
- *Cymbella*
- *Diploneis*
- *Fragilaria*
- *Gyrosigma*
- *Melosira*
- *Navicula*
- *Nitzschia*

Pinnularia
Rhizosolenia
Stauroneis
Stephanodiscus
Surirella
Synedra
Tabellaria

PYRRHOPHYTA (Dinoflagellates)

Ceratium hirundinella
Gymnodinium

ROTIFERA

Asplanchna
Kellicottia
Keratella
Ploesoma
Polyarthra
Trichocerca

ARTHROPODA
- Crustacea
  - Branchiopoda
    - Cladocera

Daphnia
Diaphanosoma leuchtenbergianum
Holopedium gibberum
Leptodora kindtii
Sida crystallina

Copepoda

Cyclops
Diaptomus
Epischura lacustris
Limnocalanus macrurus
Tropocyclops

MAGRATH LAKE

August 22, 1977

CYANOPHYTA (Blue-Green Algae)

Anabaena
Aphanizomenon
Aphanothece
Chroococcus limneticus
C. prescottii
C. spp.
Gloeotrichia
Gomphosphaeria aponina
G. lacustris
G. naegliana
Lyngbya
Mersimopedia elegans
M. major
Microcystis aeruginosa
M. (formerly *Aphanocapsa* spp)
M. wesenbergii
Oscillatoria

CHLOROPHYTA (Green Algae)

Ankistrodesmus fusiformis
Botryococcus protuberans
Chlorella?
Coccomyxa?
Coelastrum sphaericum
Dictyosphaerium pulchellum
Eutetramorus globosus
E. planctonica
Kirchneriella
Nephrochlamys (subsolitaria?)
Pediastrum boryanum
P. boryanum var. *longicorne*
P. duplex
P. integrum fo. *granulata*
P. kawraiska
Scenedesmus
Sphaerocystis
Spirogyra
Ulotrhix (zonata?)

Desmidiaceae

Arthrodesmus cf *octocornis*
Closterium
Cosmarium
Spondylosium
Staurodesmus cuspidatus fo. *divergens*
S. glaber
S. mucronatus var. *subtriangularis*
Staurastrum

CHRYSOPHYTA (Yellow-Brown Algae)
- *Dinobryon bavaricum*
- *D. divergens*
- *Monosiga* or *Salpingoeca?*

Bacillariophyceae - Preliminary Analysis
- *Amphora*
- *Anomoeoneis*
- *Asterionella*
- *Cocconeis*
- *Cyclotella*
- *Cymatopleura*
- *Cymbella*
- *Denticula?*
- *Entomoneis*
- *Epithemia?*
- *Fragilaria*
- *Gyrosigma*
- *Melosira*
- *Navicula*
- *Nitzschia*
- *Pinnularia*
- *Rhopalodia*
- *Stauroneis*
- *Stephanodiscus*
- *Surirella*
- *Synedra*
- *Tabellaria*

PYRRHOPHYTA (Dinoflagellates)
- *Ceratium hirundinella*
- *Gymnodinium?*

ROTIFERA
- *Asplanchna*
- *Kellicottia*
- *Keratella*
- *Polyarthra*
- *Trichocerca*

ARTHROPODA

Crustacea

Branchiopoda

Cladocera
- *Bosmina*
- *Ceriodaphnia*
- *Chydorus*
- *Daphnia*
- *Holopedium*
- *Polyphemus pediculus*

Copepoda
- *Cyclops*
- *Diaptomus*
- *Epischura*

Insecta
  Diptera
    Chaoboridae
        Chaoborus
    Chironomidae

McAREE LAKE

August 19, 1977

CYANOPHYTA (Blue-Green Algae)

- *Anabaena*
- *Aphanizomenon*
- *Aphanothece*
- *Chroococcus*
- *Gomphosphaeria lacustris*
- *G. naegliana*
- *Lyngbya*
- *Microcystis aeruginosa*
- *M.* (formerly *Aphanocopsa* spp)
- *M. wesenbergii*
- *Oscillatoria*

CHLOROPHYTA (Green Algae)

- *Dictyosphaerium pulchellum*
- *Dimorphococcus*
- *Eudorina*
- *Eutetramorus globosus*
- *Gloeocystis?*
- *Mougeotia*
- *Pediastrum duplex* var. *clathratum*
- *P. kawraiska*
- *Oocystis*
- *Sphaerocystis?*
- *Spirogyra*
- *Ulothrix*

Desmidiaceae

- *Arthrodesmus*
- *Cosmarium*
- *Spondylosium* and *Teilingia?*
- *Staurastrum*
- *Staurodesmus mammilatus*
- *S. triangularis* var. *americanus* or *subtriangularis* var. *inflatus*

CHRYSOPHYTA (Yellow-Brown Algae)

- *Dinobryon bavaricum*
- *D. divergens*
- *D. sociale* var. *americanum*
- *Mallomonas*

Bacillariophyceae - Preliminary Analysis

- *Achnanthes?*
- *Amphora*
- *Asterionella*
- *Cocconeis*
- *Cyclotella*
- *Diatoma?*

Fragilaria
Melosira
Nitzschia
Stephanodiscus
Synedra
Tabellaria

PYRRHOPHTYA (Dinoflagellates)

Ceratium hirundinella

ROTIFERA

Kellicottia
Keratella
Polyarthra

ARTHROPODA
- **Crustacea**
  - **Branchipoda**
    - **Cladocera**

Bosmina
Daphnia
Diaphanosoma leuchtenbergianum

Copepoda

Cyclops
Diaptomus
Epischura lacustris
Mesocyclops
Tropocyclops

McFADDEN LAKE

August 19, 1977

CYANOPHYTA (Blue-Green Algae)

Anabaena
Aphanizomenon
Gloeothece
Gomphosphaeria lacustris
Microcystis aeruginosa
M. (formerly *Aphanocapsa* spp)

CHLOROPHYTA (Green Algae)

Dictyosphaerium pulchellum
Pediastrum boryanum?
P. duplex var. *typicum* fo. *reticulatum*
Ulothrix

Desmidiaceae

Spondylosium

CHRYSOPHYTA (Yellow-Brown Algae)

Dinobryon divergens

Bacillariophyceae - Preliminary Analysis

Asterionella
Entomoneis
Gomphonema
Melosira
Navicula
Nitzschia
Pinnularia
Stephanodiscus
Synedra
Tabellaria

PYRRHOPHYTA (Dinoflagellates)

Ceratium hirundinella

PROTOZOA

Cileatea

Carchesium
Vorticella

Zoomastigophora

Monosiga

ROTIFERA

Brachionus
Kellicottia
Keratella
Polyarthra

ARTHROPODA
    Arachnida
        Acarina (water mites)
    Crustacea
        Branchiopoda
            Cladocera
                Bosmina
                Diaphanosoma leuchtenbergianum
                Leptodora kindtii
                Polyphemus
        Copepoda
                Cyclops
                Diaptomus
                Epischura
    Insecta
        Hemiptera
            Corixidae

McPHERSON LAKE

August 16, 1977

CYANOPHYTA (Blue-Green Algae)

Anabaena
Aphanizomenon
Aphanothece
Eucapsis
Gloeotrichia
Gomphosphaeria lacustris
Lyngbya
Merismopedia elegans
Microcystis aeruginosa
M. (formerly *Aphanocapsa* spp)
M. wesenbergii

CHLOROPHYTA (Green Algae)

Ankistrodesmus (formerly *Selenastrum*)
Dictyosphaerium pulchellum
Elakatothrix
Eudorina
Gloeocystis
Oocystis
Pediastrum boryanum
Planctonema lauterbornii
Sphaerocystis
Spirogyra

Desmidiaceae

Arthrodesmus cf *octocornis*
Hyalothece mucosa?
Spondylosium
Staurastrum
Staurodesmus cuspidatus var. *curvatus* or *spencerianus*
S. mammillatus fac. 3
S. pachyrhynchus fac. 3
S. spetsbergensis var. *limneticum*

CHRYSOPHYTA (Yellow-Brown Algae)

Dinobryon bavaricum
D. divergens
Monosiga or *Salpingoeca*

Bacillariophyceae - Preliminary Analysis

Asterionella
Cyclotella
Diploneis?
Fragilaria
Gyrosigma or *Pleurosigma*
Melosira
Navicula
Nitzschia

- *Pinnularia*
- *Surirella*
- *Synedra*
- *Tabellaria*

PYRRHOPHYTA (Dinoflagellates)

- *Ceratium hirundinella*

ROTIFERA

- *Asplanchna*
- *Kellicottia*
- *Keratella*
- *Ploesoma*
- *Polyarthra*

ARTHROPODA
- Crustacea
  - Branchiopoda
    - Cladocera
      - *Bosmina*
      - *Daphnia*
      - *Diaphanosoma*
      - *Holopedium gibberum*
  - Copepoda
    - *Cyclops*
    - *Diaptomus*
    - *Epischura lacustris*

MELVIN LAKE

August 23, 1977

CYANOPHYTA (Blue-Green Algae)	*Anabaena*
	Chroococcus
	Lyngbya
	Microcystis aeruginosa
	M. (formerly *Aphanocapsa* spp)
	M. wesenbergii
CHLOROPHYTA (Green Algae)	*Binuclearia?*
	Crucigenia
	Pediastrum integrum
	P. kawraiska
	Spirogyra
Desmidiaceae	*Arthrodesmus* cf *octocornis*
	Closterium kuetzingii var. *kuetzingii*
	Cosmarium
	Spondylosium sp.
	S. rectangulare
	Staurastrum
	Staurodesmus cf *dejectus* fac. 3
	Teilingia
CHRYSOPHYTA (Yellow-Brown Algae)	*Dinobryon bavaricum*
	D. sertularia
Bacillariophyceae - Preliminary Analysis	*Asterionella*
	Cyclotella
	Diatoma?
	Fragilaria
	Gyrosigma or *Pleurosigma*
	Stephanodiscus
	Synedra
	Tabellaria
PYRRHOPHTYA (Dinoflagellates)	*Ceratium hirundinella*
ROTIFERA	*Kellicottia*
	Trichocerca

ARTHROPODA
    Crustacea
      Branchiopoda
          Cladocera
                                        Bosmina
                                        Chydoras
                                        Daphnia
                                        Diaphanosoma
                                        Polyphemus
     Cyclops
                                        Cyclops
                                        Diaptomus
                                        Epischura
                                        Limnocalanus

NUMAKOOS LAKE

August 18, 1977

CYANOPHYTA (Blue-Green Algae)	*Anabaena*
	Gomphosphaeria aponina
	G. lacustris
	G. naegliana
	Lyngbya
	Microcystis aeruginosa
	M. (formerly *Aphanocapsa* spp)
	Oscillatoria
	Rivularia or *Gloeotrichia*
CHLOROPHYTA (Green Algae)	*Eudorina*
	Planctonema lauterbornii
Desmidiaceae	*Arthrodesmus* cf *octocornis*
CHRYSOPHYTA (Yellow-Brown Algae)	*Dinobryon bavaricum*
	D. divergens
	D. sertularia
Bacillariophyceae - Preliminary Analysis	*Asterionella*
	Cocconeis
	Cymbella
	Fragilaria
	Melosira
	Pinnularia
	Stephanodiscus
	Surirella
	Synedra
	Tabellaria
PYRRHOPHYTA (Dinoflagellates)	*Ceratium hirundinella*
ROTIFERA	*Asplanchna*
	Kellicottia
	Keratella
	Ploesoma
	Trichocerca

- **ARTHROPODA**
  - Crustacea
    - Branchiopoda
      - Cladocera
        - *Bosmina*
        - *Chydoras*
        - *Daphnia*
  - Copepoda
    - *Cyclops*
    - *Diaptomus*
    - *Limnocalanus macrurus*
    - *Tropocyclops*

PINE I LAKE

August 22, 1977

CYANOPHYTA (Blue-Green Algae)

Anabaena
Aphanizomenon
Gomphosphaeria aponina
G. naegliana
Microcystis aeruginosa
M. (formerly *Aphanocapsa* spp)
Lyngbya
Oscillatoria
Pseudanabaena mucicola

CHLOROPHYTA (Green Algae)

Botryococcus braunii
Dictyosphaerium pulchellum
Dimorphococcus
Gloeocystis
Pediastrum boryanum
P. duplex
Paulschuzia
Oocystis
Sphaerocystis

Desmidiaceae

Cosmarium
Staurastrum
Staurodesmus
Tetraedron limneticum

CHRYSOPHYTA (Yellow-Brown Algae)
Bacillariophyceae - Preliminary Analysis

Achnanthes?
Asterionella
Cocconeis
Cyclotella
Cymbella
Fragilaria
Gyrosigma
Melosira
Navicula
Nitzschia
Pinnularia
Stauroneis
Stephanodiscus
Synedra
Tabellaria

PYRRHOPHYTA (Dinoflagellates)

Ceratium hirundinella

ROTIFERA

- *Asplanchna*
- *Kellicottia*
- *Keratella*
- *Ploesoma*
- *Polyarthra*
- *Trichocerca*

ARTHROPODA
- Crustacea
  - Branchiopoda
    - Cladocera
      - *Alona*
      - *Bosmina*
      - *Ceriodaphnia*
      - *Chydorus*
      - *Daphnia*
      - *Diaphanosoma*
      - *Holopedium gibberum*
  - Copepoda
    - *Cyclops*
    - *Diaptomus*

PINE II LAKE

August 18, 1977

CYANOPHYTA (Blue-Green Algae)

Anabaena
Aphanizomenon
Aphanothece
Chroococcus
Gloeotrichia
Gomphosphaeria lacustris
Lyngbya
Microcystis aeruginosa
M. (formerly *Aphanocapsa* spp)
M. wesenbergii
Oscillatoria

CHLOROPHYTA (Green Algae)

Botryococcus protuberans
Dictyosphaerium pulchellum
Crucigenia fenestrata
C. rectangularis
C. tetrapedia
Dimorphococcus
Eudorina
Gloeocystis
Kirchneriella
Oocystis
Pediastrum boryanum fo. *reticulatum*
P. duplex
P. kawraiska
Scenedesmus
Schroedaria?
Sphaerocystis
Tetraedron planctonicum

Desmidiaceae

Arthrodesmus cf *octocornis*
Cosmarium
Spondylosium or *Teilingia*
Staurastrum
Staurodesmus glaber fac. 3
Xanthidium cristatum

CHRYSOPHYTA (Yellow-Brown Algae)

Chrysosphaerella multispina
Dinobryon bavaricum
D. sertularia
Gloeodinium
Gymnodinium
Synura

Bacillariophyceae - Preliminary Analysis

Achnanthes?
Asterionella
Cocconeis
Cyclotella

- *Cymbella*
- *Diatoma*
- *Entomoneis*
- *Fragilaria*
- *Gyrosigma*
- *Melosira*
- *Navicula*
- *Nitzschia*
- *Pinnularia*
- *Rhizosolenia*
- *Rhopalodia?*
- *Surirella*
- *Synedra*
- *Tabellaria*

PYRRHOPHYTA (Dinoflagellates)

- *Gloeodinium*
- *Gymnodinium*

EUGLENOPHYTA

- *Trachelomonas*

ROTIFERA

- *Asplanchna*
- *Euchlanis*
- *Filinia*
- *Kellicottia*
- *Keratella*
- *Ploesoma*
- *Polyarthra*

ARTHROPODA

- Crustacea
  - Branchiopoda
    - Cladocera
      - *Ceriodaphnia*
      - *Chydorus*
      - *Daphnia*
      - *Diaphanosoma*
      - *Holopedium*
      - *Leptodora*
      - *Polyphemus*
      - *Sida crystallina*
  - Copepoda
    - *Cyclops*
    - *Diaptomus*
    - *Epischura*
- Insecta
  - Hemiptera
    - Corixidae

UNAGIMAU LAKE

August 17, 1977

CYANOPHYTA (Blue-Green Algae)

Anabaena
Chroococcus
Gloeothece
Gomphosphaeria aponina?
G. naegliana
Lyngbya
Merismopedia
Microcystis aeruginosa
M. (formerly *Aphanocapsa* spp)
M. wesenbergii
Nostoc
Oscillatoria
Pseudanabaena mucicola
Synechococcus

CHLOROPHYTA (Green Algae)

Chlorella
Crucigenia
Dictyosphaerium pulchellum
Eudorina
Eutetramorus
Gloeocystis
Mougeotia
Oocystis
Pediastrum boryanum
Scenedesmus
Sphaerocystis
Tetraedron limneticum
Ulothrix
Volvox

Desmidiaceae

Arthrodesmus cf *octocornis*
Cosmarium
Hyalothece?
Spondylosium
Staurastrum
Staurodesmus glaber
Xanthidium cristatum

CHRYSOPHYTA (Yellow-Brown Algae)

Chrysosphaerella multispina
Dinobryon cylindricum var. *palustre*
D. divergens
D. sertularia
Mallomonas
Synura uvella

- **Bacillariophyceae - Preliminary Analysis**
  - *Asterionella*
  - *Cyclotella*
  - *Cymbella*
  - *Fragilaria*
  - *Gyrosigma*
  - *Melosira*
  - *Navicula*
  - *Rhizosolenia*
  - *Synedra*
  - *Tabellaria*

- PYRRHOPHYTA (Dinoflagellates)
  - *Ceratium hirundinella*

- ROTIFERA
  - *Asplanchna*
  - *Euchlanis*
  - *Kellicottia*
  - *Keratella*
  - *Ploesoma*
  - *Polyarthra*
  - *Trichocerca*

- ARTHROPODA
  - Crustacea
    - Branchiopoda
      - Cladocera
        - *Bosmina*
        - *Chydorus*
        - *Daphnia*
        - *Diaphanosoma*
        - *Holopedium gibberum*
        - *Polyphemus pediculus*
    - Copepoda
      - *Cyclops*
      - *Diaptomus*
      - *Epischura lacustris*

LAKE X

August 18, 1977

CYANOPHYTA (Blue-Green Algae)

- *Anabaena*
- *Aphanizomenon*
- *Aphanothece*
- *Gomphosphaeria lacustris*
- *G. naegliana*
- *Lyngbya*
- *Microcystis aeruginosa*
- *M.* (formerly *Aphanocapsa* spp)
- *M. wesenbergii*
- *Oscillatoria*

CHLOROPHYTA (Green Algae)

- *Botryococcus protuberans*
- *Eudorina*
- *Gloeocystis*
- *Pandorina?*
- *Paulschulzia*
- *Pediastrum boryanum*
- *Oocystis*
- *Scenedesmus*
- *Spirogyra*
- *Sphaerocystis*
- *Ulothrix*

Desmidiaceae

- *Cosmarium*
- *Desmidium?*
- *Staurastrum*

CHRYSOPHYTA (Yellow-Brown Algae)

- *Chrysosphaerella multispina*
- *Dinobryon bavaricum*

Bacillariophyceae - Preliminary Analysis

- *Asterionella*
- *Cyclotella*
- *Epithemia*
- *Fragilaria*
- *Gyrosigma*
- *Melosira*
- *Nitzschia*
- *Synedra*
- *Tabellaria*

PYRRHOPHYTA (Dinoflagellates)

- *Ceratium hirundinella*
- *Gymnodinium?*

ROTIFERA
- *Asplanchna*
- *Kellicottia*
- *Ploesoma*
- *Trichocerca*

ARTHROPODA
- Crustacea
  - Branchiopoda
    - Cladocera
      - *Bosmina*
      - *Daphnia*
      - *Diaphanosoma*
      - *Holopedium*
      - *Leptodora*
      - *Polyphemus*
  - Copepoda
    - *Cyclops*
    - *Diaptomus*
    - *Epischura*
    - *Limnocalanus*

ANKLE LAKE

September 22, 1978

CYANOPHYTA (Blue-Green Algae)

- *Anabaena*
- *Aphanizomenon*
- *Aphanothece*
- *Chroococcus*
- *Coelosphaerium kuetzingianum*
- *Gomphosphaerium aponina*
- *G. lacustris*
- *G. naegliana*
- cf *Lithococcus schizodichotomum*
- *Lyngbya*
- *Microcystis aeruginosa*
- *M.* (formerly *Aphanocapsa* spp)
- *M. minutissimum*

CHLOROPHYTA (Green Algae)

- *Dictyosphaerium pulchellum*
- *Elakatothrix*
- *Eudorina*
- *Geminella*
- *Gloeocystis planktonicum*
- *Kirchneriella*
- *Oocystis*
- *Pandorina*
- *Pediastrum kawraiska*
- *Planktosphaeria*
- *Sphaerocystis*
- *Ulothrix*

Desmidiaceae

- *Spondylosium*
- *Staurastrum*

CHRYSOPHYTA (Yellow-Brown Algae)

- *Chrysosphaerella multispina*
- *Dinobryon bavaricum*
- *D. divergens*
- *D. sertularia*
- *Mallomonas*

Bacillariophyceae - Preliminary Analysis

- *Asterionella*
- *Cyclotella*
- *Cymbella*
- *Diatoma*
- *Fragilaria*
- *Melosira*
- *Navicula*
- *Rhizosolenia*
- *Stephanodiscus*
- *Surirella*
- *Synedra*
- *Tabellaria*

PYRRHOPHYTA (Dinoflagellates)	
	Ceratium hirundinella
ROTIFERA	
	Asplanchna
	Filinia
	Gastropus
	Kellicottia
	Keratella
	Trichocerca
ANNELIDA	
Oligochaeta	
ARTHROPODA	
Crustacea	
Branchiopoda	
Cladocera	
	Bosmina
	Daphnia
	Diaphanosoma
Copepoda	
	Diaptomus
Insecta	
Diptera	
Chironomidae	
	Chironomus

ASWAPISWANAN LAKE

August 9, 1978

CYANOPHYTA (Blue-Green Algae)

Anabaena
Aphanizomenon
Chroocuccus
Coelosphaerium kuetzingii
Gomphosphaerium lacustris
G. naegliana
Lyngbya limneticum
Merismopedia punctata
Microcystis aeruginosa
M. (formerly *Aphanocapsa* spp)
M. wesenbergii
Oscillatoria
Pseudanabaena mucicola

CHLOROPHYTA (Green Algae)

Ankistrodesmus
Dictyosphaerium ehrenbergii
D. pulchellum
Mougeotia
Oocystis
Pediastrum boryanum
P. duplex
Planctonema
Scenedesmus
Spirogyra
Ulothrix

Desmidiaceae

Cosmarium venustum
Hyalothece
Staurastrum
Xanthidium antilopeum

CHRYSOPHYTA (Yellow-Brown Algae)

Dinobryon sertularia
D. sociale

Bacillariophyceae - Preliminary Analysis

Amphiprora ornata
Asterionella
Cocconeis
Cyclotella
Cymbella
Diatoma
Epithemia
Fragilaria
Gomphonema
Pleurosigma
Melosira
Navicula
Nitzschia

Rhizosolenia
Rhopalodia
Stephanodiscus
Stauroneis
Surirella
Synedra
Tabellaria

PYRRHOPHYTA (Dinoflagellates)
Ceratium hirundinella

PROTOZOA
- Cileatea
  - *Epistylus*

ROTIFERA
- *Colletheca*
- *Kellicottia*
- *Keratella*
- *Polyarthra*

ARTHROPODA
- Crustacea
  - Branchiopoda
    - Cladocera
      - *Bosmina*
      - *Chydorus*
      - *Diaphanosoma*
      - *Holopedium*
      - *Sida*
  - Copepoda
    - *Diaptomus*
  - Ostracoda
- Insecta
  - Ceratopogonidae
  - Chironomidae

BEARHEAD LAKE

July 20, 1978

- CYANOPHYTA (Blue-Green Algae)
  - *Anabaena*
  - *Gloeotrichia*
  - *Microcystis*
- CHLOROPHYTA (Green Algae)
  - *Pediastrum*
- CHRYSOPHYTA (Yellow-Brown Algae)
  - Bacillariophyceae
    - *Asterionella*
    - *Cyclotella*
    - *Fragilaria*
    - *Melosira*
    - *Tabellaria*
- PYRRHOPHYTA (Dinoflagellates)
  - *Ceratium*
- ROTIFERA
  - *Asplanchna*
  - *Brachionus*
  - *Kellicottia*
  - *Keratella*
  - *Notholca*
  - *Polyarthra*
  - *Trichocerca*
- ANNELIDA
  - Oligochaeta
- ARTHROPODA
  - Crustacea
    - Branchiopoda
      - Cladocera
        - *Bosmina*
        - *Chydorus*
        - *Daphnia*
        - *Diaphanosoma*
        - *Holopedium*
        - *Leptodora kindtii*
    - Copepoda
      - *Cyclops*
      - *Diaptomus*
  - Insecta
    - Diptera
      - Chironomidae
    - Trichoptera

MOLLUSCA
    Pelecypoda
        Sphaeriidae

NEMATODA

CUDDLE LAKE

July 20, 1978

CYANOPHYTA (Blue-Green Algae)	
	Gloeotrichia
	Lyngbya
CHLOROPHYTA (Green Algae)	
	Pediastrum
CHRYSOPHYTA (Yellow-Brown Algae)	
	Dinobryon
Bacillariophyceae	
	Asterionella
	Fragilaria
	Melosira
	Navicula
	Tabellaria
ROTIFERA	
	Asplanchna
	Kellicottia
	Trichocerca
ARTHROPODA	
Crustacea	
Branchiopoda	
Cladocera	
	Chydorus
	Daphnia
	Diaphanosoma
	Holopedium
	Leptodora
Copepoda	
	Cyclops
	Diaptomus

MAX LAKE

August 2, 1978

CYANOPHYTA (Blue-Green Algae)

- *Anabaena*
- *Aphanizomenon*
- *Aphanothece*
- *Chroococcus*
- *Coelosphaerium*
- *Lyngbya birgei*
- *Microcystis aeruginosa*
- *M.* (formerly *Aphanicapsa* spp)
- *Oscillatoria*

CHLOROPHYTA (Green Algae)

- *Binucleara?*
- *Botryococcus protuberans*
- *Chlorella vulgaris?*
- *Dictyosphaerium pulchellum*
- *Eudorina*
- *Oocystis*
- *Pediastrum boryanum* var. *longicornus*
- *P. duplex*
- *P. duplex* var. *gracilimum* var. *reticulatum*
- *P. kawraiska*
- *Scenedesmus quadricauda* var. *longispina*
- *Spirogyra*
- *Ulothrix*

Desmidiaceae

- *Closterium aciculare* var. *aciculare*
- *Cosmarium*
- *Staurastrum*

CHRYSOPHYTA (Yellow-Brown Algae)

- *Dinobryon divergens*
- *D. sertularia*

Bacillariophyceae - Preliminary Analysis

- *Asterionella*
- *Cymbella*
- *Fragilaria*
- *Melosira*
- *Stephanodiscus*
- *Surirella*
- *Synedra*
- *Tabellaria*

PYRRHOPHYTA (Dinoflagellates)

- *Ceratium hirundinella*

ROTIFERA	
	Kellicottia
	Keratella
	Polyarthra
ARTHROPODA	
Crustacea	
Branchiopoda	
Cladocera	
	Chydorus
	Daphnia
Copepod	
	Diaptomus
	Eucyclops

SEMPLE LAKE

July 26, 1978

CYANOPHYTA (Blue-Green Algae)	*Gloeotrichia* *Microcystis*
CHLOROPHYTA (Green Algae)	*Pediastrum*
ANNELIDA	
Hirundinea	*Helobdella* *Placobdella*
Oligochaeta	
ARTHROPODA	
Arachnida	
Acarina (water mites)	
Crustacea	
Branchiopoda	
Cladocera	*Ceriodaphnia* *Chydorus* *Daphnia* *Diaphanosoma* *Leptodora* *Polyphemus*
Copepoda	*Cyclops* *Diaptomus* *Epischura*
Insecta	
Diptera	
Chironomidae (head capsules)	*Chironomus*
Hemiptera	
Corixidae	
Malacostraca	
Amphipoda	*Hyalella azteca*
MOLLUSCA	
Pelecypoda	
Sphaeriidae	

WASS LAKE

September 17, 1978

CYANOPHYTA (Blue-Green Algae)

- *Anabaena*
- *Aphanothece*
- *Coelosphaerium kuetzingii*
- *Chroococcus*
- *Gomphosphaeria aponina*
- *G. lacustris*
- *G. naegliana*
- *Lyngbya birgei*
- *L. limneticum*
- *Microcystis aeruginosa*
- *M.* (formerly *Aphanocapsa* spp)
- *Radiocystis geminata*

CHLOROPHYTA (Green Algae)

- *Dictyosphaerium pulchellum*
- *Mougeotia*
- *Oocystis*
- *Pediastrum boryanum*
- *P. duplex*
- *Spirogyra*

Desmidiaceae

- *Arthrodesmus octocornis*
- *Closterium acerosum*
- *Pleurotaenium trabecula*
- *Staurastrum*
- *Xanthidium antilopeum*

CHRYSOPHYTA (Yellow-Brown Algae)

- *Dinobryon bavaricum*
- *D. divergens*

Bacillariophyceae - Preliminary Analysis

- *Asterionella*
- *Cymbella*
- *Diatoma*
- *Fragilaria*
- *Melosira*
- *Navicula*
- *Pinnularia*
- *Stephanodiscus*
- *Synedra*
- *Tabellaria*

PYRRHOPHYTA (Dinoflagellates)

- *Ceratium hirundinella*

ROTIFERA

- *Asplanchna*
- *Brachionus*
- *Kellicottia*
- *Keratella*
- *Polyarthra*

PROTOZOA
  Cileatea

- *Epistylus*

ARTHROPODA
  Arachnida
    Acarina (water mites)
  Crustacea
   Branchiopoda
     Cladocera

- *Alona intermedia*
- *Camptocercus?*
- *Ceriodaphnia*
- *Chydorus*
- *Daphnia*
- *Diaphanosoma*
- *Pleuroxus*
- *Sida*

  Copepoda

- *Diaptomus*

WHITEFISH LAKE

July 20, 1978

CYANOPHYTA (Blue-Green Algae)

- *Anabaena*
- *Gloeotrichia*
- *Lyngbya*
- *Microcystis*

CHLOROPHYTA (Green Algae)

- *Pediastrum*

CHRYSOPHYTA (Yellow-Brown Algae)

- *Dinobryon*

Bacillariophyceae - Preliminary Analysis

- *Melosira*

ROTIFERA

- *Kellicottia*
- *Keratella*

ARTHROPODA

Crustacea

Branchiopoda

Cladocera

- *Bosmina*
- *Chydorus*
- *Daphnia*
- *Holopedium*
- *Leptodora*

Copepoda

- *Cyclops*
- *Diaptomus*
- *Epischura*
- *Eucyclops*

WILLOW LAKE

August 23, 1978

CYANOPHYTA (Blue-Green Algae)

- *Anabaena*
- *Aphanizomenon*
- *Chroococcus*
- *Coelosphaerium kuetzingii*
- *Gloeotrichia*
- *Gomphosphaerium aponina*
- *G. lacustris*
- *G. naegliana*
- *Lyngbya*
- *Merismopedia glauca*
- *Microcystis aeruginosa*
- *M.* (formerly *Aphanocapsa* spp)
- *M. wesenbergii*
- *Radiocystis geminata*

CHLOROPHYTA (Green Algae)

- *Crucigenia rectangularis*
- *C. tetrapedia*
- *Dictyosphaerium ehrenbergii*
- *D. pulchellum*
- *Dimorphococcus lunatus*
- *Oocystis*
- *Pandorina*
- *Pediastrum boryanum*
- *P. duplex*
- *P. kawraiska*
- *P. simplex*
- *Quadrigula closteriodes*
- *Scenedesmus*
- *Tetraedron caudatum*

Desmidiaceae

- *Closterium acerosum*
- *Staurastrum*

CHRYSOPHYTA (Yellow-Brown Algae)

- *Dinobryon divergens*
- *D. sertularia*
- *D. sociale*

Bacillariophyceae - Preliminary Analysis

- *Asterionella*
- *Cyclotella*
- *Cymbella*
- *Fragilaria*
- *Melosira*
- *Navicula*
- *Rhopalodia*
- *Stephanodiscus*
- *Surirella*
- *Tabellaria*

PYRRHOPHYTA (Dinoflagellates)	
	Ceratium hirundinella
ROTIFERA	
	Colletheca
	Gastropus
	Kellicottia
	Keratella
	Polyarthra
	Trichocerca
PROTOZOA	
Cileatea	
	Epistylus
ARTHROPODA	
Crustacea	
Branchiopoda	
Cladocera	
	Bosmina
	Chydorus
	Diaphanosoma
	Holopedium
	Leptodora
Copepoda	
	Diaptomus

APPENDIX D

SEINED FISH SPECIES

LAKE	SPECIES
Whitefish	spottail shiner emerald shiner johnny darter
Bearhead	johnny darters juvenile pike
Cuddle	small perch, suckers, pike walleye fry nine spine stickleback
Semple	small pike, perch
Max	yellow perch fry spottail shiners
Aswapiswanan	johnny darter spottail shiner nine spine stickleback emerald shiner trout perch small pike
Fairy Rock	yellow perch spottail shiner white suckers emerald shiner johnny darter longnose dace
Willow	small perch, pike, white suckers spottail shiners walleye fry
Wass, Ankle	impossible to seine

APPENDIX E

MULTIVARIATE ANALYSIS OF COVARIANCE

DEEP LAKES

	Mean Depth X_1	Conductivity X_2	Catch per Gang Y	Y	Y - Y
Max	4.4	84.1	29.88	35.90	-6.02
Denison	4.84	86.8	36.67	36.60	.07
Fairy Rock	6.55	92.3	48.7	41.90	-6.8
Cuddle	7.79	85.73	51.12	51.12	0
Ankle	7.1	65.07	59.57	58.42	-1.15
Willow	14.07	103.03	70.3	72.05	1.75
Σ	44.75	517.03	296.24		
x	7.4583	86.1717	49.3733		

$SS(X_1) = 60.9867$

$SP(X_1X_2) = 118.0007$

$SP(X_1Y) = 228.7759$

$SS(X_2) = 771.9217$

$SP(X_2Y) = 165.1260$

$SS(Y) = 1086.7666$

$$60.986\ b_1 + 118.0007\ b_2 = 228.7759$$

$$18.007\ b_1 + 771.9217\ b_2 = 165.1260$$

$$-33152.792\ b_2 = 16925.228$$

$$b_2 = -0.51052$$

$$b_1 = 4.739$$

$$a = 49.3733 - (4.739 \,.\, 7.4583) - (-0.51052 \,.\, 86.1717)$$

$$= 58.021$$

$$Y = 58.021 + 4.7339\ X_1 - 0.511\ X_2$$

SHALLOW LAKES

	Mean Depth X_1	Conductivity X_2	Catch per Gang Y	Y	Y - Y
Mackerracher I	5.19	84.3	105.11	91.31	-13.80
Mackerracher II	5.25	100.6	100.84	96.81	- 4.03
Semple	1.55	87.73	73.46	54.20	-19.26
Whitefish	2.9	87.13	77.26	68.16	- 9.09
Wass	4.45	88.3	81.36	84.75	3.39
MacBride	4.28	68.2	63.52	76.96	13.44
Bearhead	2.08	83.17	50.68	58.28	7.71
Aswapiswanan	2.8	101.17	49.36	71.36	21.95
	28.5	700.6	601.59		
	2.5625	87.575	75.1987		

14.0672

-0.4614

147.2235

760.743

222.3012

3002.5929

$$14.0672\ b_1 - 0.4614\ b_2 = -67.9289$$

$$-0.4614\ b_1 + 760.743\ b_2 = 222.3012$$

$$10701.311\ b_2 = 3195.0843$$

$$b_2 = 0.29857$$

$$b_1 = 10.4755$$

$$a = 75.1987 - (10.4755 \,.\, 3.5625) - (.29857 \,.\, 87.575$$

$$= 11,732464$$

$$Y = 11.732 + 10.476\ X_1 + 0.299\ X_2$$

MULTIVARIATE ANALYSIS OF VARIANCE

A. Box test for equality of dispersions

M statistic = 16.0763
F statistic = 1.9463
with n_1 = 6 and n_2 = 795 d.f.
integrated F probability = 0.9297
determinant of within groups = $2.2021 \cdot 10^{8}$
determinant of total = $1.1536 \cdot 10^{9}$
Wilk's lambda = 0.1909
generalized R^2 = 0.8091
Rao's F approximation = 14.1288
with n_1 = 3 and n_2 = 10 d.f.
integrated F probability = 0.9993

B. Univariate ANOVA with n_1 = 1 and n_2 = 12 d.f.

variable	MS among	MS within	F	probability
X_1	52.0372	6.2545	8.32	0.9867
X_2	6.752	127.722	0.0529	0.1939
Y	2286.6931	340.7799	6.7102	0.9772

means

	variables		
group	X_1	X_2	Y
1 (deep)	7.4583	86.1717	49.3733
2 (shallow)	3.5625	87.5750	75.1987

common means

	X_1	X_2	Y
	5.2321	86.9736	64.1307

dispersion matrix

	X_1	X_2	Y
X_1	6.2545	9.7949	31.3333
X_2	9.7949	127.722	32.2856
Y	31.3333	32.2856	340.7799

total ss/cross products matrix

	X_1	X_2	Y
X_1	127.0910	98.7948	31.0457
X_2	98.7948	1539.4165	511.6843
Y	31.0457	511.6843	6376.0523

within groups matrix

	X_1	X_2	Y
X_1	75.0538	117.5393	375.9995
X_2	117.5393	1532.6645	387.4271
Y	375.9995	387.4271	4089.3592

among groups matrix

	X_1	X_2	Y
X_1	52.0372	-18.7445	-344.9538
X_2	-18.7445	6.7520	124.2571
Y	-344.9538	124.2571	2286.6931

C. Multivariate analysis of covariance

determinant of within groups = 2175.6221

determinant of total = 6205.9477

Wilk's lambda = 0.3506

generalized R^2 = 0.6494

Rao's F approximation = 18.5249

with n_1 = 1 and n_2 = 10 d.f.

integrated F probability = 0.9984

Test F with 1 and 10 d.f. = 18.5249

Critical F with 1 and 10 d.f. = 4.96 at P = 0.05

APPENDIX F

REPORTS ON MECHANICAL EQUIPMENT AND ECONOMICS

ROTATIONAL PULSE FISHING
REPORT ON MECHANICAL EQUIPMENT

BY

A. FRIESEN

MARCH 1978

INTRODUCTION

Due to the logistics of a remote, fly-in commercial fishing operation in which fish are transported by air to a central packing station, shore facilities must be available to hold at least two days catch at lakeside. The basic design chosen was patterned after the system described by K. R. Scott in the paper entitled *"Portable refrigerated Fish Holding Unit for Remote Freshwater Fisheries"*. (1970. The basic components of the shore facilities consist of the following items.

1. Portable, insulated fish shed.
2. Cooling unit.
3. Water pressure system c/w chlorinator and filter system.
4. Ice machine and ice bin.
5. 5kW power plant.

The following sections will discuss in more detail the 5 major components in the shore facility.

1. Portable insulated fish shed

The most desirable features in the holding building design are as follows:

A. Commercially available (as a standard item).

B. Knockdown capability, utilizing "cam-locks" devices to latch panels together.

C. Easily transportable in small aircraft, (two foot panel widths).

D. Cam-locks should be operable using a simple Allen wrench.

E. 2" to 3" polyurethane insulation sandwiched between aluminum sheets. Wood frame can be included to provide strength and durability to panel edges. Floor panels should be clad with heavy gauge galvanized or stainless steel sheets.

F. Coved floor panels to prevent water from entering the cam-lock mechanism.

G. Assembly should not be critically dependent on the floor being set on perfectly flat ground.

H. Panels should be able to withstand rough handling associated with a remote operation and simple to repair if damaged.

I. Building size should be simply increased by adding more panels

Bally Case and Cooler Inc. supplied their standard 8' x 10' x 8'6" walk-in cooler for this project. All panels were filled with 4 inches of polyurethane insulation. Although the panels are thicker than required, the extra insulation aids in decreasing the refrigeration load but adds to the bulkiness during shipping. This size of shed can adequately hold an estimated 4,800 pounds of fish. Our model did not have coved floor panels which allowed water and slime to corrode the cam-locking devices thus hindering their smooth operation. For the same reason, the water and slime caused an odor and bacteria to build up in the joints between the floor and the wall panels. During assembly of the building, we found it difficult to align many of the wall and ceiling panels to allow proper operation of the cam-locks. After complete erection, several cam-locks could not be successfully locked in place, even though precautions had been taken to provide a flat surface for the floor assembly.

The building has only been set up twice and is already showing signs of deterioration. Many of the hexigonical shafts which are used to activate the cam-locks have become "rounded" which makes the special assembly wrench slip during tightening. Some of these shafts have fallen out and become lost, making that individual cam-lock useless until repaired. Some panels have been damaged because the aluminum skin has

has separated from the insulation leaving it even more susceptible to damage and almost impossible to repair.

Part way through the fishing season, it was necessary to cut a small drain hole in the bottom of a back wall panel to facilitate easier cleaning and draining of the building.

After only one summer's operation, it appears the building is not ideally suited to this type of operation but is at present, the most suitable we could obtain without custom construction.

2. Cooling Unit

In order to maintain the temperature of the storage shed at about $4^{\circ}C$ a 1/3 hp self contained refrigeration unit was used. The unit consists of an insulated pad with a refrigeration compressor mounted on the top and a cooling coil attached to the bottom. A hole is cut in the roof of the shed to allow the cooling coil to protrude into the shed while the mounting pad forms a tight seal around the edges of the hole. A thermostat controls the compressor to maintain a constant temperature in the shed. A strong angle iron frame was constructed around the compressor to protect it from rough handling. A similar frame will be added to protect the cooling coil. The electrical cord for the unit should be as short as possible to prevent damage to the cord or plug during transportation.

To avoid cutting a large hole in the roof, future plans for the cooling unit include separating the cooling coil from the compressor using flexible refrigeration lines equipped with quick couplers. Thus only a small hole in the roof, just large enough to accommodate the refrigeration lines and control wiring is needed.

This type of system would be advantageous during handling because of the smaller individual components, but would also be prone to contamination when the refrigeration lines are coupled and decoupled. Future field trails will show if this type of arrangement is suitable for remote locations.

To replace the borrowed unit used during the first year of tests, a custom built unit has been purchased from Cimco Ltd. for $ 1,021.05. This ½ hp 115V unit utilized readily obtainable off-the-shelf components. A low pressure control has been substituted for the thermostat in order to provide compressor protection in the event of refrigeration loss as well as protection from coil frosting. The major disadvantage of this control is a larger room temperature differential.

3. Water Pressure System

Filtered, chlorinated, and pressurized water is needed for washdown purposes and for ice production at the lakeside. Jacuzzi Canada Ltd. has a pre-assembled shallow well water pressure system which is ideally suited for this operation. The system consists of a 1/3 hp electric centrifugal pump, one hydrocel pressure tank, stand, pressure, switch, shallow well kit, and foot valve. All that is needed to make the system functional is to add a 3/4" plywood base plus the suction and discharge lines and interconnecting fittings. In order to chlorinate the water, a Chemtech chlorinator is also mounted on the plywood base. The chlorinator pump is wired in parallel with the water pump at the pressure switch thus causing concentrated chlorine solution to be injected at a tee fitting inserted at the discharge of the water pump.

The chlorine solution is mixed and stored in a Rubbermaid plastic garbage can which doubles as a durable storage container during moving. Due to the high level of particulate matter in lake water near the shoreline it is importnat that a water filter be installed only in the water line to the ice machine and not the washdown water line in order to prevent premature filter plugging. An Aqua-Pure Dirt/Rust type filter (model AP10) with a replaceable filter cartridge (model AP110) was used with good results. A cleanable water strainer supplied with the ice machine was installed at the inlet to the Aqua-Pure filter to strain large particles. The water system performed well, despite the adverse operating conditions. The only difficulty occurred when a sediment build-up in the suction line and pump casing caused the system to occasionally lose its prime. A thorough cleaning remedied this problem.

4. Ice Machine

Approximately 1,000 pounds of ice is necessary to pack the estimated daily fish catch of 2,000 lbs. An air cooled Scotsman model MF5AE 230/60/1 ice machine was selected for three basic reasons.

1. Running current was lower than all competitive models (Important when operating a generator).
2. Rated ice producing capacity of 1,000 lbs/24 hours.
3. Modular design and easily removable access panels.

A new unit comes bolted to a wood crating base. If this base is left attached, four rope type handles can easily be attached by drilling small holes through the wood, threading the rope through the holes, and knotting the ends.

It is important that the water supply to the ice machine not be interrupted while the machine is producing ice. A low refrigerant pressure control should stop the unit in the event of water failure, but we found this did not always work. Since water interruption is inevitable in a field operation, this control should be checked to ensure it is properly set. To be 100% sure of unit protection, a low water pressure switch should be added and wired in series with the low refrigerant pressure control.

An ice bin 4' x 4' x 4' was constructed from ½" plywood painted with white epoxy paint on the inside and insulated with 1" thick styrofoam glued to the exterior. The bin frame work must be strong enough to support the weight of the ice machine which is placed on top of it. The bin was functional and served the intended purpose even though signs of wear were evident toward the end of the summer. A better design would be to construct 6 insulated panels each 4' x 4' x 2" thick and assemble them with clasps to form a cube 4' x 4' x 4". One panel would be fitted with a hatch to provide access to the ice.

5. Generator

The most critical component in the assembly is the generator. The ice machine, water pump, chlorinator, and cooling unit all rely on electricity to operate. Since reliability and long life are of prime importance, a heavy duty 1,800 RPM generator has priority over the much lighter weight 3,600 RPM models. A diesel type generator was not chosen due to excessive weight and different fuel requirements than outboard motors. Our final selection was a 5,000 watt Onan generator with the following specifications:

1. Contractors model 5.0 CCK-3CE/2236
2. 1,800 RPM
3. 5,000 Watt (Unity power factor).

4. 385 lbs.

The generator performed well and easily handled the high starting currents imposed by the electric motor load. At one point, the generator was run on the gasoline-oil mixture used in outboard motors and suffered no ill effects other than fouled spark plugs. The generator comes with a well designed carrying frame making handling of the heavy unit as easy as possible.

SUMMARY

Even though many of the components chosen for the portable lakeside plants do not meet all the design criteria, the system functioned smoothly for the most part, and maintenance was not too time consuming. At no time did the equipment hinder the fishing effort nor was there any product loss attributed to the poor equipment performance.

Cost and weight summary of the described fly-in fish plant. (Prices shown are approximate government costs).

Item	Cost	Weight
1. Building	$ 3,000.00	1,330 lbs.
2. Cooling Unit	1,050.00	150 lbs.
3. Water System	200.00	70 lbs.
4. Chlorinator	120.00	5 lbs.
5. Ice Machine	1,900.00	230 lbs.
6. Generator	1,900.00	385 lbs.
7. Miscellaneous	300.00	100 lbs.
Total	$ 8,470.00	2,270 lbs.

ROTATIONAL PULSE FISHING

ECONOMIC REPORT

BY

P. THOMPSON

MARCH 1978

Pulse Fishing Experiment Economic Report

This analysis assumed that the 1977 pulse fishing experiment on Mackerracher Lakes and Denison Lake was operated as a business operation. The analysis used cost data collected from the actual operation as well as imputed costs. Revenues and costs for the 6 fishermen and their 3 boats have been consolidated for this presentation. An income statement of revenues and costs is presented in Table 1.

Table 1.

Income Statement Summer 1977 Operations

Revenues		
Fish Sales - Mackerracher Lakes	$ 11,328	
Denison Lake	8,789	
	20,117	
Freight Subsidy	6,051	
Total Revenues		26,168
Direct Costs Fishing Operations		
Fuel, Oil etc.	866	
Food Costs (est.)	2,880	
Outboard Maintenace	288	
Miscellaneous Expenses	648	
Freight Expense to Leaf Rapids	10,973	
Fishing Wages (in Manitoba Minimum Wage)	9,937	
	25,592	576
Indirect Costs Fishing Operations		
Fishing Licences	60	
Boat Insurance	64	
Shore Equipment Insurance	232	
Shore Operations	100	
Shore Facility Maintenace	170	
Equipment Freight Expense	2,501	
	3,127	(2,551)
Depreciation Expenses		
Boats	540	
Engines	1,275	
Gillnets	445	
Miscellaneous	276	

Bally Building	350	
Generator Set	450	
Ice Machine and Equipment	460	
Weigh Scales	69	
	3,865	(6,416)
Net Income		(6,416)
Cash Flow		(2,551)
Cash Balance (Funds Available to Fishermen)		7,386

Table 2 presents harvest statistics while Table 3 presents some cost statistics for the hypothetical enterprise.

Table 2.

Pulse Fishing Experiment 1977 Harvest Statistics

	Pounds Harvested Marketed Weights	Gross Fish Revenue	Average Price Per Pound
Mackerracher Lakes			
Pickerel	$ 6,449	$ 5,152	$ 0.7989
Whitefish	24,134	5,202	0.2155
Northern Pike	9,246	973	0.1050
Total	39,829	11,328	0.2844
Denison Lake			
Pickerel	$ 3,657	$ 2,915	$ 0.7971
Whitefish	23,338	5,444	0.2333
Northern Pike	2,990	430	0.1438
Total	29,985	8,789	0.2934
Total			
Pickerel	$ 10,106	$ 8,067	$ 0.7982
Whitefish	47,472	10,649	0.2243
Northern Pike	12,236	1,401	0.1145
Total	69,814	20,117	0.2882

Table 3.

Pulse Fishing Experiment 1977 Cost Statistics

	Average Total Revenue Per Pound (subsidized)	Average Variable Cost Per Pound	Average Operating Cost Per Pound	Average Total Cost Per Pound	Contribution to Profit
Mackerracher Lakes	$ 0.3687	$ 0.3834	$ 0.4227	$ 0.4709	$ -0.1022
Denison Lakes	0.3833	0.3444	0.3966	0.4611	-0.0778
Total	0.3748	0.3666	0.4144	0.4667	-0.0919

Given the 1977 operation the hypothetical enterprise is not financially viable. The enterprise would have sustained a net loss for 1977 of $ 6,461 and an operating loss of $ 2,551. While an accounting loss does not determine long term viability, the accumulation of an expected negative cash flow of $ 2,551 indicates that the enterprise would be unable to provide a return on invested capitol of $ 19,397. It must be stressed that returns to labour are less than adequate. It was assumed that labour was paid at the Manitoba minumum wage rate for the 72 days of actual fishing activity. While the adequacy of the assumption given the entrepreneural skills of labour needed for the operation can be questioned, it should be noted that the cash generated by the operation would have totalled $ 7,386. As the funds available for payment for the labour of the fishermen, this sum represents less than 75% of what would be considered minimum wages.

Reasons for Poor Financial Performance

The following factors contributed by varying degrees to the financial loss:

1. Fishing Effort. The fishing crews could have expended more fishing effort than they did. The three boats average 29.3 nets lifted per day on the Mackerracher Lakes and 41.4 nets lifted per day on Denison Lake. This is considered to be low. It is considered that 60 nets per day would be medium effort and entirely feasible. Had more effort been expended, the financial loss would have been lessened. The incremental cost of lifting more nets per day will be very slight in going from an average of 45 ato 60 nets. The incremental revenue of the other hand will be significant. Two points

would appear to be important. First, revenue per day will be greater and profits will be increased. Second, the increase in effort may cause the fish stock to be fished down sooner resulting in lower total costs as the number of days fishing is decreased.

A related point deals with gillnet mesh size. To the extent that the 4½ mesh size used in the experiment is not the most physically efficient mesh size in catching whitefish and especially pickerel, the use of the wrong mesh size contributed to the financial loss. The cost of employing efficient versus inefficient mesh size will be substantially the same. Thus revenues lost and the extra costs incurred for the reasons stated above, are important factors contributory to non-viability.

2. Lake Selection: Species. With estimated average operating costs of about 41¢ per pound, the species available for exploitation is a very important factor and the success of an enterprise will depend to a large degree upon the amount of high priced species available. For the two lakes fished in 1977, pickerel accounted for less than 15% of the total catch. Obviously, if the pickerel proportion of the catch could be increased, the operation would be more viable. For example, had pickerel represented 30 per cent of the total catch instead of 15 per cent, the enterprise would have increased gross fish revenues by 32 per cent, incurred a net loss of $ 1,034, and a positive cash flow of $ 2,831. Lakes should not only be selected for pickerel because whitefish

is bound to make up the major part of the catch from any lake every effort should be made to obtain lakes classed for export whitefish. Export whitefish prices are likely to exceed the price of continental whitefish by at least 35% and thus would contribute significantly to reducing the financial loss.

3. Lake Selection: Freight Expense. Freight charges on fish shipments accounted for 43 per cent of variable operating expenses. This is extraordinarily high. Not only should every effort be made to reduce the freight expenses incurred by efficient freight management, but consideration should also be given so soundness of selecting remote lakes. Some lakes are going to be beyond the margin of economic viability, it is therefore necessary that more accessible lakes be considered.

4. Timing of Fishing. For both lakes the fishing crews fished too long. In each case the lakes were fished for a significant number of days longer than they should have. As a fish stock is fished out, the daily revenues will decrease relative to the daily costs of operation. Profits are maximized (or losses minimized) when marginal costs of operation are equated with marginal revenues. It can be seen losses were at a minimum for Mackerracher Lakes on the 20th day and increased for the next 24 days, while losses reached another minimum at Denison Lake on the 64th day and then increased for the remaining 8 days. In each case marginal costs surpassed marginal revenues. Thus, fishing took place for 24 consecutive days of Mackerracher Lakes where marginal costs exceeded marginal

revenues and for 8 consecutive days on Denison Lake. This contributed significantly to the size of the financial loss incurred. In the future, losses can be minimized if proper attention is paid to daily revenues versus daily costs.

Potential for Pulse Fishing

Should cost and revenue trends as seen in 1977 continue, pulse fishing cannot be considered as an economically viable enterprise. The potential cash flow provides no return to invested capital and a return to labour which is less than the Manitoba minimum wage. It should be noted that the analysis assumed no financing of capital, had it, returns to labour would have been reduced.

Pulse fishing appears to be a very practical enhancement to the primary fishing industry. Nevertheless, the 1977 operations indicate that there are severe limitations imposed by the combined effects of distance, unfavourable species composition and levels of fishing effort less than optimal which is likely to be very difficult to overcome. The importance of the above noted factors and the possibility of ameliorating them, however, needs more classification before the potential profitability of pulse fishing can be assessed.

On the basis of operating during 1977, a point of concern should be noted. The Manitoba freight subsidy received by the operation totalled $ 6,051 or 30 per cent of fish revenues and it accounts for 82 per cent of the cash generated by the enterprise. In the absence of the freight subsidy, the concept of pulse fishing in remote lakes will clearly be uneconomic. Furthermore, it is unlikely that remote pulse fishing will become economic should the freight subsidy be withdrawn or phased out in the future. Figure 2 shows unsubsidized marginal revenue well below marginal costs for most fishing activity, making it unlikely that fixed costs can be recouped. Furthermore, it should be noted that the amount of the subsidy would have been in excess of the amount of cash generated for payment to labour had the analysis assumed capital financing. Thus, there is reason to question the possibilities for pulse fishing in remote lakes, especially in the absence of subsidies.

More important however, is the appropriateness of promoting fishing enterprises in remote locations which must depend upon a subsidy to carry on. To the extent that a subsidy can promote economic viability of an enterprise and subsequently be withdrawn there is little problem, but where an enterprise is likely to depend upon a perpetual subsidy to guarantee its existence, such an alternative would appear to be a poor alternative for promotion by the public sector. The problem is magnified when an indirect subsidy is less effective in benefitting a target group then would be a direct subsidy.

In conclusion, it is suggested that future emphasis for pulse fishing should be directed towards lakes with a known potential for viability. The important aspects determining viability will be species composition, accessibility and operational efficiency.